UNDERSTANDING THE DYNAMIC SYSTEM OF TERRORIST – GOVERNMENT INTERACTION

THESIS

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Abstract

The nature of action and reaction that forms the basis for terrorist – government interactions creates a dynamic system. Understanding how this dynamic system behaves in response to key government activities can help the government better control the overall behavior of the system. The system dynamics methodology is one tool that can help the government solve specific behavioral problems within the overall system.

This research shows the ability of system dynamics to help develop government policy towards terrorism that can directly affect a terrorist's behavior. It supports a government policy of offensive action instead of defensive reaction. It also identifies the primary variables and parameters of the overall system at an aggregated level. This research effort is the genesis of a future research stream capable of helping the government manages their terrorism policy. The last chapter of this study suggests additional steps in this line of research to develop a tool that can help the government control the dynamic system of terrorist–government interactions.

UNDERSTANDING THE DYNAMIC SYSTEM OF

TERRORIST – GOVERNMENT INTERACTION

I. Introduction

The September 11th 2001 attacks against the United States of America highlighted America's vulnerability to hostile terrorist actions within the nation's borders. The attacks also demonstrated the speed and lethal capability of modern global and regional terrorist organizations. For the U.S. government to effectively respond to these threats, it must develop a better understanding of the dynamic system formed by the interactions between it and terrorist organizations.

1.1 Background

The attacks of September 11th have changed the face of U.S. national security. To quote Secretary of Defense Donald H. Rumsfeld (2002:22-23),

> During the Cold War, we faced a fairly predictable set of threats. We knew a good deal about our adversary and its capabilities, and we fashioned the strategies and capabilities needed to deter them. And we were successful. … As we painfully learned on September 11, the challenges of the new century are not nearly as predictable as were those of the last. Who would have imagined, only a few months ago, that terrorists would take commercial airliners, turn them into missiles, and use them to strike the Pentagon and the World Trade Center, killing thousands? In the years ahead, we will probably be surprised again by new adversaries who may strike in unexpected ways.

As pointed out by Secretary Rumsfeld, one of the United States' new enemies is terrorist groups that threaten it and its interests with unconventional warfare and terrorism.

The rally cry for U.S. efforts against this new threat of terrorism was the events of September 11th, which dramatically changed the American public's perception of homeland security. However, the threat of terrorism to the U.S. is not new; in fact, it started well before the end of the Cold War and has increased significantly since the fall of the Soviet Union. To understand the threat of terrorism, it is important to define terrorism, review the relevant history of traditional terrorism, identify the significant factors in the evolution of modern terrorism, identify modern government counterterrorism operations, and recognize the system behaviors created by the interactions between the government and modern terrorist organizations.

1.1.1 Definition of Terrorism. In its most basic form, terrorism is about affecting some type of change in the society to which the terrorist organization belongs. The spectrum of change can vary greatly; it may be greater autonomy for a specific ethnic group, a change in political leadership or form of government, the creation of a separate nation for the oppressed group, or the complete destruction of a target nation or culture (Hoffman, 1998:45-129). Although a major tool for affecting this change is public relations via violence, a mismanaged public relations campaign can lead to public outrage and adverse governmental and international reprisals (Hoffman, 1998:155). Over the years, the concept of terrorism has developed a negative connotation; therefore, any group identified as a terrorist organization will find it difficult to develop a positive public relations campaign to accomplish its goals. Likewise, people and nations are less likely to provide financial, technical, logistical, or other types of support to organizations that are considered terrorists (Hoffman, 1998:30-31).

Because of the importance of public relations, at the heart of the problem of defining terrorism is one's point of view (Hoffman, 1998:31). If a person or nation supports the social status quo, then they normally label those who want to change that status quo via some violent method to be a terrorist. However, if a person or nation does not support the social status quo, then they normally label those who want to change the status quo as freedom fighters, revolutionaries, or some other socially acceptable name; furthermore, they also claim that the only methods available for these individuals to affect the desired social change is via violence (Hoffman, 1998:31).

In fact, many authors claim that the words terror, terrorism, and terrorist have been so widely used and applied that there is no true consensus regarding their exact meaning (e.g., Hoffman, 1998; Quillen, 2002a; Howard and Sawyer, 2002). For instance, Hoffman (1998) and Howard and Sawyer (2002a) dedicated the entire first chapter of their books on terrorism to reviewing the problem of defining it. Quillen (2002a:281) probably summarizes this dichotomy best in stating, "Far too many trees have been slain and far too much ink spilled already debating the exact definition of terrorism." A classic example of this problem was the attempt by the United Nations (UN) to internationally define and take a stand on terrorism following the 1972 terrorist attack at the Munich Olympics. However, the UN reached an impasse between the Western powers and several third world countries who saw terrorism as the only possible way for many small revolutionary movements and small countries to combat the military might of the established national and/or world powers (Hoffman, 1998:31-32).

Despite this lack of consensus regarding a definition for terrorism, this research effort needs a definition to provide a context for its results. Therefore, the U.S. Department of Defense definition of terrorism will be used:

> the unlawful use of–or threatened use of–force or violence against individuals or property to coerce or intimidate governments or societies, often to achieve political, religious, or ideological objectives. (Hoffman 1998:38)

To better comprehend the difficulties in defining terrorism, it is necessary to add another level of detail to our definition. Traditionally, terrorist organizations act within a specific geographical region to affect social change for a specific group of people. This changed with the 1968 Palestinian hijacking of an El Al commercial flight from Rome to Tel Aviv, an act which some experts claim was the birth of modern international terrorism (Hoffman, 1998:67; Gunaratna, 2002:1). For the purpose of this research, modern terrorism will be divided into three selected types: Domestic (or Traditional) Terrorism, International Regional Terrorism, and International Global Terrorism. To understand how these types were selected, it is useful to review the relevant history of traditional terrorism and the evolution of modern terrorism

1.1.2 History of Traditional Terrorism. The use of violence as a mechanism for change is not a new concept to humanity; terrorism has been around in one form or another throughout human history. However, the origin of the word terror and its association with violent political change are credited to the French Revolution (1787-1799). The French revolutionaries used a system of terror to round-up and punish supporters of the French Monarchy and other parties considered to be a threat to the new democracy. The standard method of punishment was beheading. Under this initial

context, terrorism was seen as a necessary, if not positive, tool of the government to establish the fledgling democracy (Hoffman, 1998:15).

Over the next 150 years, other European revolutionaries, constitutionalists, anarchists and anti-establishment forces established the common association of terrorism with anti-governmental forces. It was Carlos Pisacane who is credited for developing the terrorism theory of "propaganda by deed" (Hoffman, 1998:17). However, it was the Russian constitutionalist group called Narodnaya Volya that is credited with first practicing "propaganda by deed" with the double suicide bombing of Tsar Alexander II (Hoffman, 1998:17-18). The European terrorists' struggles against monarchies have been credited for setting in motion the chain of events that started World War I (Hoffman, 1998:21).

In the 1930s and 1940s, the atrocities of Hitler and Stalin shifted the definition of terrorism back to a tool of government, instead of anti-government forces, in order to ruthlessly establish and maintain power (Hoffman, 1998:25). This was short lived though, as three factors from World War II helped reshape the face of terrorism as a tool of anti-government forces. First, Japan's initial victories over European and American forces in the Pacific theater proved that these colonial powers were not invincible (Hoffman 1998:46). Second, the development of the Atlantic Charter in 1941 included articles that affirmed the right of a populace to self-determination and a voice in developing territorial boundaries (Hoffman, 1998:47). The third factor was the Jewish Holocaust, which eventually led to postwar sympathy for the Jews and restoration of their historical homeland (Hoffman, 1998:53-56). The resulting establishment of the Jewish

state of Israel dislocated many Palestinians, a major factor in today's Israeli-Palestinian conflict and a significant source of today's terrorism (Hoffman, 1998:69-71).

After World War II ended, many Western colonies expected to be freed from colonial rule. When this did not happen, post-World War II anti-colonial terrorism began to materialize (Hoffman 1998:25-26). It was during this timeframe that several Jewish terrorist groups located in Palestine began attacking British colonial forces, with the distinct goal of using violence to draw international public attention to their cause of Jewish statehood (Hoffman, 1998:50-53). However, international sympathy for the Jews as a result of the Holocaust created a politically correct environment in which Jewish terrorists were referred to as "freedom fighters," which represented a much more positive connotation in the world of public relations (Howard and Sawyer, 2002:48).

The Jewish struggle, which was eventually supported by many American politicians and the United Nations, demonstrated that terrorist activities are historically defined by who won (Hoffman, 1998:54-56). Eqbal Ahmad, a major activist scholar, often stated, "To begin with, terrorists change. The terrorist of yesterday is the hero of today, and the hero of yesterday becomes the terrorist of today" (Howard and Sawyer 2002:48). To support this statement, Ahmad points out that at least two Israeli prime ministers, including Menachem Begin, appeared in "Wanted" posters during the initial Jewish struggles. He also points out that the same Afghan mujahideen "freedom fighters" praised by President Regan as allies against the "Evil Empire" of the Soviet Union became members of the Taliban and the global terrorist organization Al Qaeda (Howard and Sawyer, 2002:48).

The Jewish terrorist model of the late 1940s affected the development of many other anti-colonial terrorist groups, such as the Algerian-based National Liberation Front (FLN) (Hoffman, 1998:56). In turn, the FLN had an effect on the development of later ethno-nationalist terrorist groups, such as Yasser Arafat and the Palestine Liberation Organization (PLO) (Hoffman, 1998:60). In similar fashion, the PLO became an example for many of today's terrorist groups (Hoffman 1998:75-80). Ironically then, an argument can be made that former Jewish terrorist groups initiated an evolution of terrorism that resulted in the anti-Israeli terrorists that plague Israel today.

1.1.3 Evolution of Modern Terrorism. From the outset of terrorism, the majority of terrorist groups were geographically restricted in their motivations, capabilities, and areas of operations. As previously stated though, the 1968 Palestinian hijacking of an El Al commercial flight from Rome to Tel Aviv is considered by many to be the birth of modern international terrorism (Hoffman, 1998:67; Gunaratna, 2002:1). This hijacking was soon followed by the infamous 1972 Palestinian attack on the Israeli Olympic athletes in Munich. These two events not only provided the global media attention the Palestinians sought, they also started a trend in which terrorists began to travel to other nations to execute attacks against their target audiences (Hoffman, 1998:68 and 71-73). This internationalization of terrorism is the primary difference between modern terrorism and traditional terrorism.

The 35-year history of modern terrorism since 1968 has been an evolution of motivation, weaponry, and support. However, the two most significant factors in this evolution are the technological developments in the areas of modern communication and

transportation and the emergence of more liberal democracies throughout the world. These factors are briefly addressed below to establish a context for the overall document.

The historical fact is that the technological development of communications over the 20th century has forever changed global human interactions. Even over the last 20 to 30 years, the development of real-time communications through phones, 24-hour news reporting, and the Internet have revolutionized the amount and quality of information people have at their discretion. This fact has not been lost on the terrorist community. The ability of news organizations to report real-time news is important to terrorists because it helps spread their desired message across the globe almost instantaneously and fulfills the old adage that "a picture is worth a thousand words." One does not have to look any further then the events of September 11th to see this point. Besides providing access to real-time media, developments in communications technology also provide terrorists tools (e.g., secure satellite communications and the Internet) to enhance their organizational effectiveness and capabilities (Medd and Goldstein, 1997:295).

Although 20th century changes in transportation technologies were not as drastic as those in communications, they were just as significant. The most important area was the development of commercial air travel, which allowed people to travel great distances in hours as opposed to days or weeks. The use of aircraft and air travel in terrorist activities is clear. In fact, since the 1968 El Al hijacking, commercial airliners have been used as a target for hijackings and bombings (Hoffman, 1998:137 and 149) and more recently as a weapon as demonstrated in the September 11th attacks (CNN.com, 2002:2).

In addition to the faster and more capable communications and transportation technologies available to terrorists today, the emergence of liberal democracies around

the world has provided terrorists an environment in which they can thrive. These democracies, with greater emphasis on personal freedoms, guarantee individuals certain rights and privileges. Therefore, terrorist groups are able to function in these democratic societies with a certain amount of operational security for their activities. More importantly, the government response to terrorism in a democracy, unlike that in a monarchy or totalitarian government, is usually complicated by politics and bureaucratic processes (Crenshaw, 2001:335; Hoffman, 2002:314).

1.1.4 Government Counterterrorism Operations. Governments started developing their modern counterterrorism capabilities in the 1970s when the common terrorist tactics were "events of duration," such as hijackings and hostage taking. As terrorism evolved, the terrorists utilized more conclusive methods, such as bombings and assassinations, because they offered the counterterrorism forces less time to mount a response (Medd and Goldstein, 1997:282-283). Since the late 1970s, most governments have developed a multi-agency response within their own government (Veness, 2001:409). In more recent years, as highlighted by the response to September 11th attacks, it has become growingly apparent that the disjointed responses of individual nations has not been enough to counter the threat of terrorism; therefore, world governments have started to cooperate in the battle against terrorism on a regional and global level.

As governments begin to cooperate, it is important to understand that counterterrorism actions can be divided into three categories: prevention, proactive action, and post-event investigation. Prevention is classified as actions designed to detect and overtly disrupt terrorist operations. Proactive action consists of covert intelligence

gathering to interdict terrorist organizations and their operations. Post-event investigation is the collection of evidence to identify and convict the individuals or groups responsible for a terrorist action (Veness, 2001:413-414).

1.1.5 System Behaviors. These counterterrorism actions by governments establish a system of interactions that are driven by the behaviors of both terrorists and governments. To understand these interactions, it is important look at how the output of one entity serves as an input for the other entity. The government is acting on what it thinks or knows the terrorists are doing, while the terrorists are trying to identify where the government is most susceptible to attack. The ensuing system formed by these interactions is dynamic because each group is reacting to the actions of the other while trying to obtain and/or maintain a distinct advantage over the other entity within the system. This dynamic interaction is shown graphically in Figure 1.

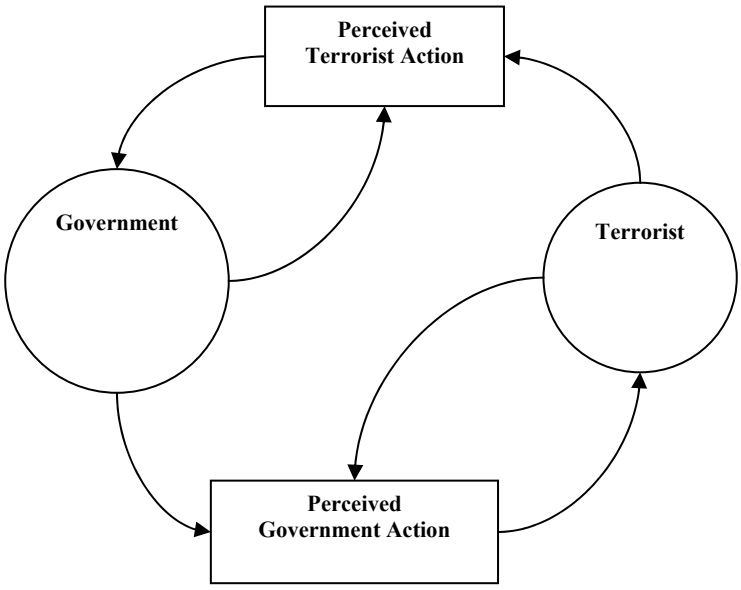


Figure 1. Dynamic Interaction between Terrorism and Government

Since social change is at the heart of a terrorist's motivations, there are three possible long-term outcomes for a terrorist group. The first possible outcome is that the terrorists are successful in affecting the desired government and/or social change, as with the Israeli terrorists in post-World War II Palestine (Hoffman, 1998:56). The second possible outcome is that the terrorists continue their struggle until they are destroyed or imprisoned, as with Narodnaya Volya (Hoffman, 1998:19). The final possible outcome is that the terrorist organization realizes that their cause is not worth fighting for any more, as with many leftist terrorist groups who suffered ideologically from the fall of the Soviet Union (Hoffman, 1998: 83-84). Any true solution to terrorism is inherently long-term (Hoffman, 2002:314) and is outside the scope of this research. This study is not concerned with the long-term effects of terrorism, but rather with the existing interactions between governments and terrorists.

1.2 Thesis Problem Statement

From the previous description of interactions, it can be said that terrorist organizations and the government form a cyclic system of action and reaction. A better understating of this system and its basic structure will help the government manage the terrorist–government interaction. Therefore, the problem statement for this research is, "In order to effectively counter terrorism, the government must better understand the dynamic system of interactions between itself and the terrorist at an aggregate level."

1.3 Objectives

Given this broad problem statement, the overall objective of this research is to describe the underlying interactions comprising the terrorism–government system in system dynamics terms. The more specific objectives are listed below.

1.3.1 Objective 1. Since terrorism is difficult to define, this study will attempt to identify the primary interactions between terrorist organizations and the government by iteratively disaggregating the model boundary.

1.3.2 Objective 2. This study will provide some insight into how the system behaves and how changes to these primary interactions affect the modeled behavior.

1.4 Methodology – A Systems Dynamics Overview

System dynamics provides a methodology that allows one to develop and understand the relationships within virtually any type of system. It has been applied in a wide variety of settings; a few examples include the areas of business, human health, and public policy (Sterman, 2000:41-42). In all cases, the use of system dynamics principles is focused on describing the behavior of a system.

> Systems dynamics is fundamentally interdisciplinary. Because we are concerned with the behavior of complex systems, system dynamics is grounded in the theory of nonlinear dynamics and feedback control developed in mathematics, physics, and engineering. Because we apply these tools to the behavior of humans as well as physical and technical systems, system dynamics draws on cognitive and social psychology, economics and other social sciences. (Sterman, 2000:4-5).

System dynamics is a practical modeling methodology often used to address a single question within a complex system, thus allowing a more simplistic view of the overall

system. In this approach, system dynamics iteratively adds layers of complexity on top of the simplistic view until the appropriate level of detail has been reached.

1.5 Summary

The United States of America has entered a new phase of its history. The physical boundaries, which have served to protect the U.S. from foreign attacks with few exceptions, have been negated by the wonders of modern information and transportation technologies. To better defend the American homeland, it is important for the U.S. government to understand the aggregate-level terrorist and government activities that provide significant insight to the dynamic system of terrorist–government interaction.

II. Literature Review

The literature review conducted for this research is divided into four primary areas. First, the concept of modern terrorism is expanded beyond the definitions developed in Chapter I. Second, the actual threat created by modern terrorism is addressed from a domestic, regional, and global perspective. Third, the manner in which governments respond to terrorism is addressed. Fourth, system dynamics is examined in relationship to conflict modeling and terrorism as a methodology for studying terrorist–government interactions.

2.1 Types of Modern Terrorism

Terrorists have traditionally restricted their activities to a specific geographical area with the goal of influencing change for a specific group of people within that area. However, as stated in Chapter I, the 1968 Palestinian hijacking of an El Al commercial flight demonstrated that advancements in technology allowed terrorists to expand their areas of operations and influence, thus giving rise to modern international terrorism (Hoffman, 1998:67; Gunaratna, 2002:1). This realization was reinforced by the Palestinian attack on Israeli athletes during the 1972 Olympics in Munich, Germany. These two terrorist events effectively confirmed that modern technologies were providing terrorists with new opportunities resulting from increased capabilities (Hoffman, 1998:68 and 71-74). The way terrorist organizations capitalized on these opportunities served as the primary means to categorize modern terrorist groups into three categories: Domestic

(or Traditional) Terrorism, International Regional Terrorism, and International Global Terrorism. A brief summary of these categories is provided in Table 1.

Table 1. Types of Modern Terrorism (FBI, 2002:1-3; Hoffman, 1998:45-129)

Type of Terrorism	Organizational Goals or Objectives	Primary Geographical Area of Operations	Primary Historical Period	Recent Examples
Domestic Terrorism	Domestic/ National	Domestic/ National	Pre-1968 (Many still exist today)	Shining Path, Abu Sayyaf
International Regional Terrorism	National or Regional	Regional or Global	1970s – Present	Real IRA, Islamic Resistance Movement (HAMAS)
International Global Terrorism	Regional or Global	Global	Post Cold War - Present	Al Qaeda

2.1.1 Domestic Terrorism. Domestic terrorism is a term used by the U.S. to describe terrorist activity within the nation's borders. Under this description, the Federal Bureau of Investigations (FBI) is assigned the responsibility for counterterrorism operations to fight domestic terrorism, which is defined by the FBI as follows.

> Domestic terrorism is the unlawful use, or threatened use, of force or violence by a group or individual based and operating entirely within the United States or its territories without foreign direction committed against persons or property to intimidate or coerce a government, the civilian

> population, or any segment thereof, in furtherance of political or social objectives. (FBI, 1999:ii)

However, domestic terrorism for the purpose of this research is defined as terrorist groups who have organizational goals and/or objectives that are limited to a domestic or national level and have a primary geographical area of operations that is also limited to the domestic or national. This definition, in many ways, is just a generic application of the FBI definition on a global level.

In addition to the FBI's responsibilities, the State Department is one of several U.S. agencies responsible for monitoring terrorism outside the U.S. and maintains the Designated Foreign Terrorist Organization (FTO) list. Of the 35 groups currently on this list, 13 fall into the domestic terrorism category (FBI, 2002:1-3). Of these 13 groups, 3 operate in Columbia; 2 each in the Philippines, Egypt, and Greece; and 1 each in Algeria, Sir Lanka, Turkey, and Peru. Examples of these domestic terrorist organizations are the Abu Sayyaf group (Philippines), 17 November (Greece), and Shining Path (Peru) (FBI, 2002:1-3).

Besides the 13 domestic groups on the State Department's FTO list, several domestic organizations within the U.S. have been identified as terrorists or linked to terrorist acts (FBI, 1999:17-20). However, the FBI operates on a per incident basis and the loose affiliation of most U.S. terrorist organizations prevents direct connection of the organization to terrorist events unless the organization takes credit for the attack (FBI, 1999:17-20). Therefore, the FBI does not publish a list of these organizations. Instead, they have divided these domestic terrorist groups into three categories: Right-Wing, Left-Wing, and Special Interest. Of the known terrorist incidents in 1999, only the special

interest groups, specifically the environmental terrorist groups, claimed responsibility for their attacks (FBI, 1999:3-6). In fact, the FBI credited five domestic groups with terrorist acts or links to terrorist acts during 1999. Two of these groups, the Animal Liberation Front (ALF) and Earth Liberation Front (ELF), are classified as global terrorist groups by this study because their motivation is global and their extensive use of the Internet gives them a global capability (FBI, 1999:20).

Domestic terrorism is similar to traditional terrorism. Even though their areas of operation and influence are limited, they benefit from contact or formal alliances with other terrorist groups; therefore, these groups are not classified as traditional terrorists. Examples of domestic terrorist organizations that benefit from contact with other terrorists groups are Abu Sayyaf, who has been linked with the global terrorist group Al Qaeda (Gunaratana, 2002:66; Chalk, 2001:251), and various Columbian terrorists groups, who may have benefited from explosives training from the Irish Republican Army (Department of State, 2002:63-64).

2.1.2 International Regional Terrorism. For the purpose of this research, international regional terrorism is defined as terrorist groups who have organizational goals and/or objectives that are limited to a national or regional level and have a primary geographical area of operations that is either regional or global. A regional geographical area refers to an area larger than a single nation, such as the Middle East, but smaller than a continent. Of the 35 FTOs on the State Department's list, 21 can be classified as international regional terrorists. Of these 21 groups, 12 have primary ties to the Middle East, 6 to Asia, 2 to Europe, and 1 to Africa. However, most of these groups operate in more than one region, and several conduct operations within the U.S. and Europe. A few

examples of international regional terrorists groups include the Real Irish Republican Army (Real IRA) operating in Europe and the Islamic Resistance Movement (also known as HAMAS) and Hezballah groups operating in the Middle East (FBI, 2002:1-3).

According to the State Department's FTO list, regional terrorists dominate today's worldwide terrorist threat; besides being the largest category in numbers, regional terrorists groups are also some of the oldest groups in the world (FBI, 2002:1-3). The average life of a terrorist organization is 13-14 years (Gunaratna, 2002:13). However, some of the oldest terrorist groups today are regional ethno-nationalist/separatist groups (e.g., the Provisional IRA, the Al-Fatah, the PLO, and the Basque group Euskadi ta Askatasuna) who have all been active for at least 30 years (Hoffman, 1998:170-171).

In addition to being older and more established, many regional terrorist organizations have a very homogeneous membership. In fact, they are often identified as religious terrorists because of their homogeneity rather than as secular terrorists based on their motivations. Key examples are the PLO and the IRA; both groups are fighting for redefinition of the current political boundaries for their region. However, they have a strong religious component because their membership is entirely Islamic or Catholic, respectively (Hoffman, 1998:87).

As stated earlier, the Palestinians are credited for initiating the trend of publicizing regional terrorism on a global level. However, the Palestinian's goals are still regional, i.e., the reestablishment of the Palestine state and the defeat of Israel. A major reason that regional dissidents choose terrorism as their primary method of operation is that globally publicized regional terrorism often produces faster results than diplomatic methods as illustrated below (Hoffman, 1998:68).

> As Zehdi Labib Terzi, the PLO's [Palestinian Liberation Organization] chief observer at the United Nations, reflected in a 1976 interview, 'The first several hijackings aroused the consciousness of the world and awakened the media and world opinion much more – and more effectively – than 20 years of pleading at the United Nations.'

The Palestinian attacks during the 1972 Munich Olympics reinforced this point as millions watched the event unfold on television. In fact, a major lesson of this event was that a failed terrorist operation can still be considered a huge success if there is enough major media coverage of the event. "In terms of the publicity and exposure accorded to the Palestinian cause, Munich was an unequivocal success – a point conceded by even the most senior PLO officials" (Hoffman, 1998:73).

2.1.3 International Global Terrorism. For the purpose of this research, international global terrorism is defined as terrorist groups who have organizational goals and/or objectives that are regional or global in nature and have a primary geographical area of operations that is multi-regional or global. Of the 35 FTOs listed by the State Department, only the Al Qaeda group is classified as a global terrorist organization. Two of America's environmentally focused terrorist groups, ALF and ELF, fit this definition; however, these organizations do not routinely kill people to get their terrorist message across to the desired audience.

On the other hand, bin Laden and Al Qaeda have quite possibly taken the next step in the evolution of modern terrorism--the globalization of terrorism (Gunaratna, 2002:11). Al Qaeda was created by Abdullah Azzam and Osama bin Laden towards the end of the Afghan war with the Soviet Union. Abdullah Azzam is credited for conceptualizing Al Qaeda in 1987 not only as a way to create an Army to defend Islam but also as a way to capitalize on the capabilities and manpower of the Afghan mujahdin

forces that had been assembled to expel the Soviets from Afghanistan (Gunaratna, 2002:3-4, 21-22). With their charter from Azzam to protect Islam, Al Qaeda supports Islamic forces around the world with funding, training, and other support (Gunaratna, 2002:31, 71-72).

There are three major organizational factors that set Al Qaeda apart from other terrorists groups: their inherited infrastructure and training, their international and multinational membership, and their global business-like structure. Because of their connection to the Afghan mujahdin, Al Qaeda obtained much of its Pakistani and Afghan infrastructure from the supporters of the mujahdin, which had included the U.S. and the Saudi Royal Family. Similarly, much of their training methods were adopted from the U.S. and other western countries. For example, the 7,000-page Encyclopedia of Afghan Jihad, a primary Al Qaeda training document, was taken from U.S. and British military manuals (Gunaratna, 2002: 55, 71-72).

Similarly, Al Qaeda's membership has no regional boundaries, unlike the majority of regional terrorist groups. This was originally a result of the Afghan war with the Soviets in which Osama bin Laden led the multinational mujahdin forces. The multinational nature of their membership has continued primarily because Al Qaeda recruits the best and most devout individuals from other terrorist groups. An additional benefit of this practice is that it also provides Al Qaeda a deep supply of veteran recruits. Al Qaeda maintains an elite reputation within the Islamic terrorist community; therefore, many terrorists consider it a great honor to be invited to officially join Al Qaeda's membership. This recruiting process makes it very difficult for countries to infiltrate spies into the Al Qaeda organization (Gunaratna, 2002:3 and 8).

Al Qaeda, under bin Laden's leadership, has created a global terrorist network that supports Islamic extremists across the globe (Europe, Asia, Africa, the South Pacific, etc.) and actively operates terrorist cells in Europe and North America (Gunaratna, 2002:55). Much of bin Laden's leadership is based on his education in business, which has led to the common comparison of Al Qaeda to a multinational corporation and to bin Laden being dubbed the "CEO of Terrorism" (Gunaratna, 2002:68-69; Hoffman, 2002:306-307). This can be seen in the organizational structure of Al Qaeda shown in Figure 2. At the top of the organization, bin Laden serves as the company president. The major divisions of the company consist of operations (military committee), finance (Finance and Business), public affairs (media and publicity), and religious guidance (Fatwa and Islamic study). Like any modern corporation, bin Laden has developed a global network as a significant part of the Al Qaeda structure. This global network consists of terrorist cells worldwide and strategic alliances with many domestic and regional Islamic terrorist organizations, thereby giving these organizations a global capability while increasing the domestic and regional capabilities of Al Qaeda (Gunaratna, 2002:8,45 and 57). This has made Al Qaeda the premier terrorist organization of the 21st century (Hoffman, 2002:307).

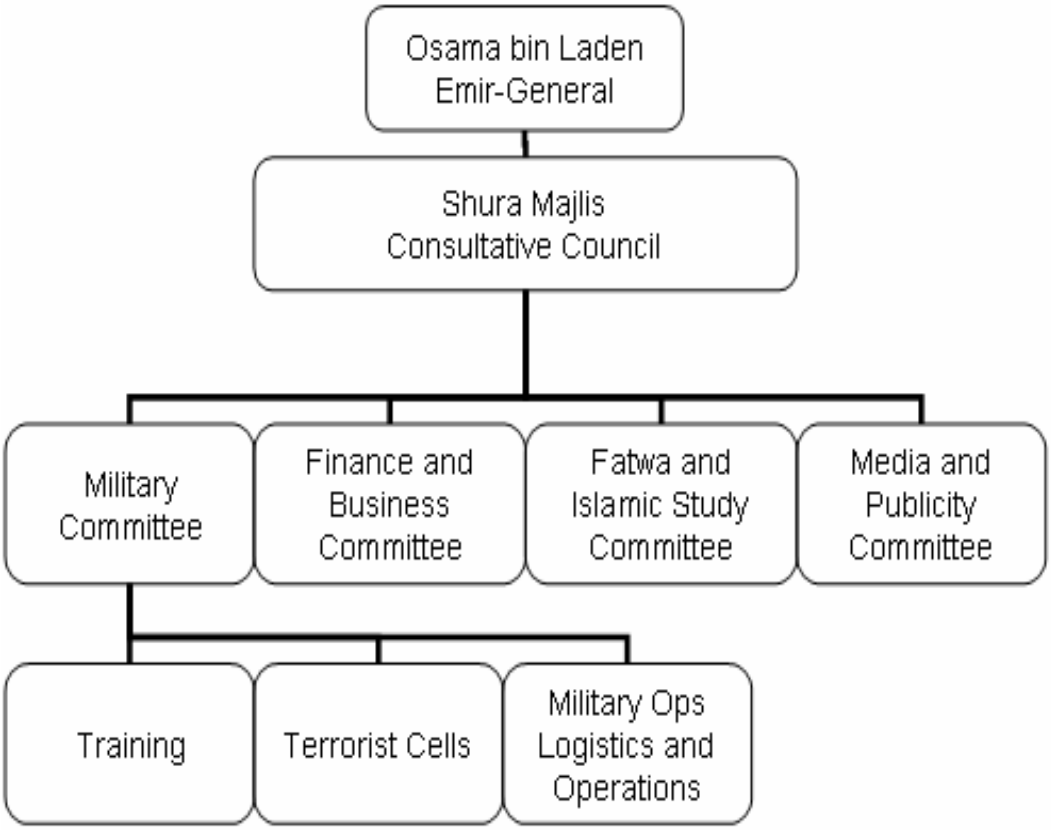


Figure 2. Al Qaeda's Organizational Structure

On February 23, 1998, Osama bin Laden declared war on the United States when he decreed that it is the holy duty of every Muslim to kill Americans and allies of Americans (Gunaratna, 2002:45). The stated objective of this war was to drive U.S. troops out of the Kingdom of Saudi Arabia (Gunaratna, 2002:7). Al Qaeda has subsequently conducted terrorist attacks against U.S. targets on land with the 1998 U.S. Embassy bombings in Africa, at sea with the 2000 U.S.S. Cole bombing in the Indian Ocean, and from the air with the September 11th suicide attacks in the U.S. (Gunaratna, 2002:7). Through these attacks, Al Qaeda demonstrated their ability to plan, coordinate,

and execute multiple attacks almost simultaneously and over large distances with mass causalities (Hoffman, 2002:306).

2.2 Modern Terrorist Threat

Some terrorist groups, such as the IRA, openly take credit for their attacks (Hoffman, 2001:417). Other groups, most notably Al Qaeda, go out of their way to hide their terrorist activities from their target nations (Gunaratna, 2002:3). Some groups, such as the ALF and ELF, do not actively seek to kill people; instead, they focus on sabotaging infrastructure (Howard and Sawyer, 2002:264-269). Other terrorist groups are engaged in a "Holy War" to kill as many of the enemy as possible and actively seeking weapons of mass destruction to accomplish their goals; the most prominent of these groups are Al Qaeda and Aum Shinrikyo (Gunaratna, 2002:48-49; Howard and Sawyer, 2002:215; Hoffman, 1998:121-127). To better understand the modern threat a terrorist group poses, it is important to examine some key characteristics of terrorism: support, motivation, and weaponry.

2.2.1 Support. One of the most important characteristics of a terrorist group is its support base. While the type and source of support provided to a terrorist organization has a significant effect on the group's capabilities, it also limits a terrorist organization by the level of violence that is acceptable to its supporters (Hoffman, 1998:94,168,189). The more direct the support, the greater the chances are that the target government or the international community may hold the supporters directly liable for the actions of the terrorist group. Examples of this include the bombing of Pam Am Flight 103 over Lockerbie, Scotland, and the 1986 bombing of a disco bar in West Berlin. These terrorist

acts were attributed to Libya because of its direct support for terrorists in the late 1980s (Department of State, 2002:67). However, the most significant example of this has to be the American military retaliation for the September 11th attacks. The Afghan Taliban government's failure to turn over key Al Qaeda members resulted in a devastating war with the U.S. that eventually led to the collapse of their government (Gunaratna, 2002:51-52; Department of State, 2002:10).

2.2.1.1 Types of Support. Regardless of the person(s), organization, or government providing the support to a terrorist organization, there are many different types of support. For the purpose of this research, five types of support have been identified: Moral, Logistical, Financial, Training, and Safe Haven. The motives and capabilities of the supporters often determine the level of support provided, as seen below.

2.2.1.1.1 Moral Support. The most basic and traditional type of indirect support that can be provided to a terrorist group is moral support. When individuals, private organizations, and/or governments publicly identify with the goals and objectives of the terrorist group, they are providing moral support. Depending on one's perspective, moral support may appear highly illogical at times. A prime example is Osama bin Laden. Despite the horrific nature of the September 11th attacks, bin Laden's public and moral support in many Islamic countries remained very high. Some of his supporters even speculated that the Israelis or the U.S. orchestrated the attacks to involve the U.S. in the fight against Islam and to frame bin Laden. In some cases, the support for Osama bin Laden has increased as he is seen as a hero standing up to the onslaught of the U.S. government (Gunaratna, 2002:52-53).

Moral support can be an important factor in the success or failure of a terrorist organization. Utilizing post-war sympathy because of the Holocaust, Jewish terrorists were able to gain U.S. and international support, which eventually led to the restoration of their ancestral homeland. The IRA has benefited from similar support from the Irish American community in the U.S. to raise financial and logistical support for their cause in Northern Ireland (Hoffman, 1998:54; Dingley, 2001:461). However, moral support often limits the actions of the terrorist group, since any acts that violate an acceptable level of public morality can damage or remove the support being provided to the terrorist group. An example of this is the Real IRA bombing in Omagh, Northern Ireland. The Real IRA, who opposes the Northern Ireland Peace Process, set up a bombing to support their cause and claim to be the "Real IRA" as opposed to the Provisional IRA to which they use to belong. The Provisional IRA's tactics included calling government authorities to warn of any planned bombings and allow for the evacuation of innocent civilians. During one of its bombing acts, the Real IRA's phone call mistakenly moved innocent civilians closer to the bomb and resulted in 29 people being killed and over 200 being injured. The resulting public backlash strengthened the Provisional IRA, cost the Real IRA some of its support, allowed the government to pass tougher antiterrorism laws, and forced the Real IRA to limit its activity until the "dust has settled" (Dingley, 2001:451, 460-463).

2.2.1.1.2 Logistical Support. A common method of providing direct support to terrorist groups is through logistical support. While logistical support is most commonly linked to state-sponsored terrorism; it can also be provided by individuals, private organizations, and other terrorist groups. Regardless of the source, logistical

support can drastically improve a terrorist organization's capabilities through higher quality weapons, communications equipment, intelligence data, etc. Additionally, state sponsorship gives terrorists access to diplomatic transportation and facilities with which personnel and assets can be moved in a much more secure manner (Hoffman, 1998:186-187).

Iran, Syria, and Libya have traditionally provided logistical support to terrorists in the Middle East (Department of State, 2002:64-68; Hoffman, 1998:185-196). In fact, Iran is considered one of the largest arms suppliers to Middle Eastern terrorist groups. Western intelligence sources estimated that Iran sent three Boeing 747 aircraft per month to Syria in 1996 with weapons to support Middle East terrorists (Hoffman, 1998:193) In 2001, the Israeli forces captured a ship delivering over 50 tons of weapons to Middle East terrorist groups, with the majority of the weapons coming from Iran (Department of State, 2002:65).

If an organization is financially independent, it can acquire its own logistical support. For example, Al Qaeda purchased an airplane and routinely leases private aircraft to move equipment, including U.S. Stinger anti-aircraft missiles, and personnel from Pakistan to Sudan (Gunaratna, 2002:37). Al Qaeda also uses private planes to transport top-of-the-line military hardware bought in the U.S. and Europe to their operating and training locations in the Middle East. This military hardware included, among other things, 25 fifty caliber sniper rifles with 1-mile accuracy and night vision equipment, both of which were identical or near identical to that used by the U.S. military (Bergen, 2001:431; Gunaratna, 2002:37).

2.2.1.1.3 Financial Support. As with any organization, money is required for day-to-day operations and financial support can be either overtly or covertly provided to terrorists. For instance, many wealthy Middle Eastern businessmen covertly support terrorist groups through the use of several Middle Eastern businesses and banks to disguise the transactions (Gunaratna, 2002:62). Other supporters, such as many state sponsors, openly give money to terrorist organizations out of support or for services rendered (Department of State, 2002:65; Wallace, 2003:2).

However, financial support does not have to be in hard currency; a prime example is African "conflict diamonds" which can be sold for cash (Department of State, 2002:6). Many terrorist organizations have even started to seek out alternative funding sources so they are less dependent on external supporters. This has resulted in two new sources of support: criminal activity and organizational self-sustainment. Both of these sources will be covered in greater detail later in the next section.

Regardless of its form, financial support can be used by terrorists to purchase necessary equipment and sustain the organization's members. As identified earlier, Al Qaeda used their financial resources to buy and lease aircraft to gain a greater level of operational security and to buy weapons and other operational equipment (Bergen, 2001:431; Gunaratna, 2002:37). Al Qaeda also provided their members with a monthly stipend; some members even received employment with legitimate Al Qaeda business interests. Al Qaeda also provides basic medical support for members and their families (Gunaratna, 2002:33).

2.2.1.1.4 Training Support. Many terrorist groups have access to training and training materials from other terrorist groups. For example, Al Qaeda provides

training and training material on an ideological and recruiting basis (Gunaratna, 2002:31) and has published a 7000-page training manual called the *Encyclopedia of the Afghan Jihad* (Gunaratna, 2002:70). Other terrorist groups, such as the PLO, operate training camps and offer training to other terrorist groups as a source of income (Hoffman, 1998:84). In addition to this *quid pro quo* relationship, state sponsorship of a terrorist group often includes elite military training (Hoffman 1998:187). Iran, Iraq, Syria, Sudan, Libya, Afghanistan, and Cuba either currently provide or have provided training, training materials, or training bases to several terrorist groups (Department of State, 2002:63-68; Gunaratna, 2002: 30, 58-60; Hoffman, 1998:186-187). Afghanistan was a unique case since it was Al Qaeda that was supporting the government with funding and training in return for safe haven for Al Qaeda's bases and personnel (Gunaratna, 2002:58-60, and 62).

2.2.1.1.5 Safe Haven. Safe haven, which normally includes an agreement of nonextradition to hostile countries, is when a country allows terrorists to live and/or operate openly and freely in their country. Safe havens allow terrorist organizations to openly operate training and support facilities as well as engage in legitimate business activities to generate funding. Iran, Iraq, Syria, Sudan, Libya, Afghanistan, and Cuba have all provided some type of safe haven for terrorist groups (Department of State, 2002:63-68; Gunaratna, 2002:30, 58-60; Hoffman, 1998:186-187). Even Lebanon, who is not the listed by the State Department as a state sponsor of terrorism, allows anti-Israeli terrorist groups to operate openly in their country because they do not consider them to be terrorists (Department of State, 2002:57). The Afghan Taliban government openly provided a base of operations for Al Qaeda and ended up going to war with the U.S.

(Gunaratna, 2002:51-52; Department of State, 2002:10). While enjoying safe haven in Sudan, Al Qaeda started legitimate businesses, conducted training operations, and even researched chemical, biological, radioactive, and nuclear (CBRN) weapons (Gunaratna, 2002:30-37).

2.2.1.2 Sources of Support. The types of support identified above may be provided by a number of different sources. For the purpose of this research, five sources of support have been identified: Public, State, Criminal, Private and Self-sustaining.

2.2.1.2.1 Public Support. Public support, tied very closely to moral support, often provides the foundation for terrorist groups to exist. As previously mentioned, Al Qaeda is a prime example of this. Even after the atrocities of September 11th, bin Laden still has excellent public support throughout the Middle East (Gunaratna, 2002:52-53). Iraq is another example; they have openly supported terrorist groups and have been standing up to the U.S. and the international community for years. On 17 January 2003, thousands of Palestinians protested in the streets of Gaza City in support of Saddam's resistance to the U.S. Some even condemned PLO chairman Yasser Arafat for selling out the Palestinian cause to the U.S. (Wallace, 2003:1).

2.2.1.2.2 State Support. Of all sources of support, state sponsorship of terrorism continues to have the largest impact on the effectiveness of terrorist groups (Hoffman, 1998:186). State sponsorship of terrorism is not new as it has been observed throughout history. The Serbians were implicated in the terrorist assassination of the Habsburg Archduke Ferdinand that started the chain of events resulting in World War I (Hoffman, 1998:21-23). During the Cold War, the Soviets were often suspected of

sponsoring terrorism, with the most credible accusation being the 1981 attempted assassination of Pope John Paul II in Rome (Hoffman, 1998:21-23,27, and 191).

The critical turning point in open state sponsorship of terrorism came in 1979 with the Iran hostage scandal; for the first time, a weaker nation showed that it could keep a "Superpower" at bay using terrorism (Hoffman, 1998:186). Following the lead of Iran, several nations started to utilize terrorist groups as tool of foreign policy (Hoffman 1998:186; Medd and Goldstien, 1997:284). This led to terrorism being considered an alternative option to war, especially in the Middle East against Israel and the U.S. (Hoffman 1998:27,186). The U.S. State Department keeps a list of countries considered by the U.S. to be state sponsors of terrorism. The list currently includes seven countries: Cuba, Iran, Iraq, Libya, North Korea, Syria, and Sudan (Department of State, 2002:63). Prior to the events of 2001, these states have provided varying degrees of support to terrorists around the world, with Iran being considered the most active in its support. After the September 11th attacks against the U.S.; Iran, Libya, Sudan, and Syria openly condemned the terrorist attacks (Department of State, 2002:64). North Korea issued a statement that it opposed terrorism and those who support it. Cuba spoke out against the U.S. "war on terrorism" but eventually signed all 12 of the counterterrorism conventions passed by the United Nations (U.N.). Iraq was the only country on the list to openly support the terrorist attacks by indicating that the U.S. was "… reaping the fruits of [its] crimes against humanity" (Department of State, 2002:63-68).

In the past, the U.S. launched military actions against countries sponsoring terrorism, Libya in the 1980s and Afghanistan in the 1990s, with limited results (Hoffman, 1998:192-193; Gunaratna, 2002:47). However, in response to the September

11th attacks, President George W. Bush left no room for interpretation on the U.S. position towards state-sponsored terrorism when he said, "Every nation, in every region, now has a decision to make. Either you are with us, or you are with the terrorists" (Department of State, 2002:63). It is also fair to assume that the 2001-2002 U.S. invasion of Afghanistan and the toppling of the Afghan Taliban government sent a strong message to the sponsors of terrorism. It is thought that not even bin Laden fully understood the wrath that would befall him and his supporters, not only from the U.S. but from the international community (Gunaratna, 2002:51).

Another turning point in state-sponsored terrorism was the end of the Cold War. With the fall of the Soviet Union, states sponsoring terrorism began to shift from communist nations to primarily Middle Eastern countries (Laqueur, 1996: 26; Medd and Goldstein, 1997: 284). While it has not been clearly proven how much support the Soviet Union directly provided to terrorists, it is clear that the Soviets were key supporters of the majority of nations supporting terrorism. The reduction of Soviet support to these nations resulted in reduced funding levels for terrorist organizations. This caused some terrorist groups to search for new funding sources, especially those in the Middle East where there was still strong government support against the hated Israelis. Others developed partnerships with organized crime syndicates, such as narcoterrorism (Medd and Goldstein, 1997:284-285), or developed their own ways to either legally or illegally generate operating funds (Gunaratna, 2002: 61-65).

2.2.1.2.3 Criminal Support. With this shift in state-sponsored terrorism, terrorist groups being sponsored in other regions of the world were forced to find new funding sources (Medd and Goldstein, 1997:284). Some of these groups either formed

partnerships with organized crime groups or turned to committing their own crimes to raise funds (Medd and Goldstein, 1997:284-285). For example, it is estimated Colombian terrorists collected $400 million in ransom payments from 1993 to 1996 (Medd and Goldstein, 1997:284-285). During the 1990s, the Central Intelligence Agency estimates that 50 Islamic charities had some kind of ties to terrorist organizations; in many cases, terrorists were diverting funds from legitimate charities to fund their activities (Gunaratna, 2002:62). For example, Al Qaeda trains specific support cells to run credit card fraud schemes and other scams as fundraising operations (Gunaratna, 2002:62-63). Some terrorist organizations abandoned their ideological roots and strictly became a "gun for hire" outfit (Hoffman, 1998:187).

2.2.1.2.4 Private and Self-sustaining. Many terrorist organizations, especially in the Middle East, generate funds through private donations and self-sustaining businesses and investments; once again, Al Qaeda has perfected this method of fundraising more than any other terrorist group (Gunaratna, 2002:60-66). However, the PLO was one of the first terrorist groups to open training camps and charge other terrorist groups. They were also one of the first to begin accumulating wealth through investments. In the 1980s, it was estimated that the PLO's annual income was $600 million, with approximately $500 million of that coming from investments (Hoffman, 1998:84). The Abu Nidal organization, another Palestinian group, is estimated to be worth over $400 million, which was acquired through "gun for hire" operations and financial investments (Hoffman, 2002:187).

Al Qaeda has been the most successful terrorist organization in obtaining private funding and becoming a self-sustaining organization, primarily because bin Laden turned

Al Qaeda into a global business (Hoffman, 2002:307; Gunaratna, 2002:68-69). He used his business degree to establish several legitimate business and non-governmental groups to generate and launder money (Chalk, 2002:251; Gunaratna, 2002:61-69). He also established "The World Islamic Front for Jihad Against the Jews and Crusaders" to form a global network for the organization. Within this organization, there was strict compartmentalization of subordinate groups and an emphasis on strict monetary controls (Gunaratna, 2002: 65). Because bin Laden was so successful in creating a global terrorist organization, Al Qaeda serves as a private sponsor for other terrorist groups joining their coalition against Israel and the U.S. The most telling key of Al Qaeda's success was that they were the first terrorist organization to provide financial and military support to their host government (Gunaratna, 2002:62). Al Qaeda's support for other terrorist organizations, even governments, who share common motivations, could represent the next evolution in the sponsorship of terrorism.

2.2.2 Motivation. Changes in the sponsorship of terrorism have also resulted in changing motivations. During the 1970s, terrorists were motivated primarily by political ideologies and were often referred to as freedom fighters. In the 1980s, these political motivations were reinforced by the Islamic anti-West movement sponsored by Iran; the 1980s also saw an increase in economic motivations. In the 1990s, economic reasons moved to the forefront of terrorists' motivations (Medd and Goldstein, 1997:283-285). Today, there are three primary types of motivation for modern terrorists: Secular/Political, Religious, and Special Interest.

2.2.2.1 Secular/Political. Historically, the motivation of terrorists has waivered between secular/political and religious; however, secular/political motivations were the

dominant force until the 1980s (Hoffman, 1998:90). Although many secular terrorist groups, such as the PLO and the IRA, have distinct religious affiliations, their overarching goals are politically motivated; these terrorist groups choose terrorism as a methodology because it is perceived to be more effective in achieving the desired political and/or cultural changes (Hoffman, 1998:168). This is clearly demonstrated in the earlier quote from Zehdi Labib Terzi that "The first several hijackings aroused the consciousness of the world and awakened the media and world opinion much more – and more effectively – than 20 years of pleading at the United Nations" (Hoffman, 1998:68). Even though both the PLO and the IRA have strong religious ties, both groups desire political independence from their current ruling governments, thereby making them secular organizations (Hoffman, 1998:87). It is critical for secular organizations to maintain an environment of public support within the regional or international community. This constrains their methodology; the indiscriminate use of violence and the resulting injuries and deaths of innocent civilians would damage their public support (Hoffman, 1998:87 and 168).

2.2.2.2 Religious. In a study of mass causality bombings (25 fatalities or more) for the last half of the 20th century, 47 of 76 were religious in nature and accounted for 3,952 of 5,690 fatalities; however, the same study noted that, "Although it is true that 'religious' terrorists are indeed much more willing to kill in large numbers, it is far from clear how one can differentiate the religious from the other terrorists" (Quillen, 2002a: 287-288). The key difference between a secular and religious terrorist organization is how they justify their terrorist activities; religious terrorists believe that the use of extremely violent terrorism is ordained by God (Hoffman, 1998:89-90). Religious

terrorists believe that God's opinion is the only one that matters; therefore, they have little concern for what any outside individual or group may think about their attacks (Hoffman, 1998: 94). Religious terrorists feel it is their religious duty to eliminate an entire group of people.

In Islamic terrorism, the Fatawa is a religious edict issued by an Islamic holy man proclaiming that God has sanctioned the terrorist attack; thus, the Fatawa is considered the most important motivation for Islamic terrorists (Gunaratna, 2002:7 and 84; Hoffman, 1998:97 and 191). Currently, the threat of Al Qaeda and its brand of Islamic terrorism are of particular interest to the U.S. From its inception, Al Qaeda has considered itself to be the vanguard of warriors defending the Islamic faith. When the U.S. and coalition forces were asked to drive Iraqi forces from Kuwait, Al Qaeda was outraged that their all-Muslim army was not used. Al Qaeda's rage continued to build when U.S. forces, referred to as infidels by the terrorists, did not leave their "Holy Land" in Saudi Arabia (Gunaratna, 2002:27-29)

A close kin to religious terrorists are religious cults and hate groups. These organizations often exhibit the same extreme religious zealot qualities. One of the most dangerous terrorist organizations in the world, the Japanese religious cult Aum Shinirkyo, has consistently tried to use weapons of mass destruction to fulfill their religious motivations (Hoffman, 1998:126-127). Within the U.S., some white supremacists and anti-government groups have been linked with terrorist attacks. The most infamous of these domestic terrorist attacks was the Oklahoma City bombing (Hoffman, 1998:87 and 168).

2.2.2.3 Special Interest. Special interest terrorism is a category used by the FBI to refer to types of terrorism that are based on environmental and economic reasons and not the traditional motivations. There have been a few terrorist events related to economics and the World Trade Organization; however, the majority of events related to special interest terrorism have been linked to environmental extremists such as the ALF and ELF. Although environmental terrorism is extremely active, especially in North America, the relatively low level of violence associated with it does not constitute as much of a threat as that posed by international regional and global terrorism (FBI, 1999:32-33).

2.2.3 Weaponry. Combined with these troubling developments in sponsorship and motivation, there has been a rising trend of "superterrorism," which is defined as the significant increase in the number of fatalities and injuries per terrorist attack. The era of superterrorism began with the 1993 bombing of the World Trade Center (Medd and Goldstein, 1997:286). Since then, incidents include the 1995 nerve gas attack in a Tokyo subway, the 1995 bombing of a federal building in Oklahoma City (classified as domestic terrorism), and the September 11th suicide attacks using commercial airliners. This movement towards mass casualties has resulted in an escalation in the use of more advanced weapons by terrorists. This study will focus on three types of terrorist weapons: traditional guns and bombs, conventional mass casualty weapons, and Weapons of Mass Destruction (WMD)/Chemical, Biological, Radiological, and Nuclear (CBRN).

2.2.3.1 Guns and Bombs. Terrorists have traditionally used guns and bombs to achieve their goals. Over the years, these weapons provided terrorists with sufficient flexibility to control the level of violence being used (Hoffman, 2001:417). Guns and

bombs remain the weapons of choice for terrorist organizations that must show discretion in their attacks to maintain their support structures (e.g., Real IRA, 17 November, and Basque Fatherland and Liberty, a.k.a., ETA). The only advancement in the use of these weapons has been the availability of more sophisticated explosives (Medd and Goldstein, 1997; 283).

2.2.3.2 Conventional Mass Casualty Weapons. Since the birth of modern terrorism in 1968, there is historical evidence that terrorist actions have become increasingly violent. Religious terrorism is believed to be a significant factor in this rise in mass casualty terrorism, which is defined as any terrorist event causing 25 or more deaths (Quillen, 2002a:280). Under this definition, terrorist events that cause massive injuries, such as the 1995 Tokyo sarin gas attack, are not considered mass casualty terrorism (Quillen, 2002a:280). Including the September 11th attacks, which used unconventional means with conventional weapons, terrorists have been successful using conventional bombs to produce mass casualty results. This is attributed to two factors: the established knowledge of terrorists in the use of conventional explosives and their recognition of the complexity involved in the use of CBRN weapons on a mass scale. However, this has not stopped terrorists from trying to procure and develop the use of CBRN weapons.

2.2.3.3 WMD/CBRN. Weapons of mass destruction (WMD) are chemical, biological, or nuclear (CBN) weapons originally design by nations to generate large casualties against enemies during times of war. More recently, the terminology has been changed to CBRN to denote the use of nuclear technology to produce radiological dispersion weapons, which are less damaging than a full-scale nuclear device but easier

to produce and still psychologically effective. After all, terrorism is a psychological form of social conflict and no weapons have instilled more psychological fear in humanity than WMD/CBRN. Although there is no knowledge of a terrorist organization fielding a fully capable nuclear weapon, terrorists have planned and/or attempted to use radiological, chemical, and biological weapons. Therefore, the primary concern is to ensure that the few nations who have military grade WMD/CBRN technology maintain strict controls to prevent it from falling into the hands of terrorist organizations.

The means required to produce WMD/CBRN weapons is very scientifically involved and the only group to have any success is Aum Shinirkyo, a Japanese religious cult with an unusually high cadre of professional scientists. Although they are the only terrorist group to repeatedly attempt to use CBRN technology, they have had the most success with chemical weapons. The two most notable examples are the 1994 nerve gas attack in Tokyo that killed 7 and hospitalized 250 and the 1995 sarin gas attack of a Tokyo subway in which 12 were killed and 5000 were injured (Hoffman, 1998:126; Medd and Goldstein, 1997; 285). This group has also tried to use biological weapons, botulinus and anthrax, on several occasions but with no real success. There is a strong concern that the Aum Shinirkyo terrorist group has an interest in using nuclear WMD since they are known to have purchased a farm in Australia for the purpose of mining uranium (Hoffman, 1998:125).

2.3 Modern Government Responses to Terrorism

The ever increasing flexibility and capability of terrorist organizations cause problems for the U.S. and other nations who are the targets of terrorism and are trying to defend themselves. These factors make defending a "free" nation extremely difficult due to the near infinite number of targets that are available to terrorists (Office of Homeland Security, 2002:vii). Additionally, governments are usually in the position of planning and reacting to the last big attack; therefore, their actions lag those of the terrorist. This was evident in the birth of modern counterterrorism. Recall that the start of modern international terrorism is usually attributed to the 1968 hijacking of an El Al commercial flight from Rome to Tel Aviv. However, most countries, especially European countries, did not start to organize specialized police and military units to deal specifically with the threat of terrorism until after the Palestinian attack on Israeli athletes at the 1972 Olympics (Hoffman, 1998:72-73). To develop a better understanding of the interactions between terrorist organizations and governments, this section of the literature review explored three areas: stages of modern counterterrorism, national and international cooperation in counterterrorism, and the long-term solution to terrorism.

2.3.1 Stages of Modern Counterterrorism. The countries with the most successful counterterrorism operations have been those that relied on a long-term strategy of prevention, proactive operations, and post-event investigation (Veness, 2001:414). The U.S. Office of Homeland Security (OHS) identified six critical mission areas for U.S. counterterrorism operations: intelligence and warning, border and transportation security, domestic counterterrorism, protecting critical infrastructure, defending against catastrophic terrorism, and emergency preparedness. It also stated, "The first three mission areas focus primarily on preventing terrorist attacks; the next two on reducing

our Nation's vulnerabilities; and the final one on minimizing the damage and recovering from attacks that do occur" (Office of Homeland Security, 2002:viii). These mission areas can be aligned with the three areas of counterterrorism identified by Veness (2001).

2.3.1.1 Prevention. Prevention is intended to passively interdict terrorist activity during the reconnaissance, preparation, attack, and escape phases through an overt government presence, especially local law enforcement personnel and defensive actions to protect critical assets (Veness, 2001:414). In essence, prevention involves taking defensive steps against a suspected threat with the goal of preventing damage to the suspected target. This can be better understood by reviewing the critical mission areas emphasizing prevention: border and transportation security, protecting critical infrastructure, and defending against catastrophic terrorism (Office of Homeland Security, 2002:viii-x). Although domestic counterterrorism could be classified as prevention, it will be discussed as a proactive operation.

Border and transportation security attempts to prevent terrorists from using the domestic and global transportation system to conduct their terrorist operations within the U.S. without significantly hampering the legitimate free flow of people and commerce comprising the heart of American society (Office of Homeland Security, 2002:21-22). An example of this type of preventive action would be the 14 December 1999 apprehension of a terrorist transporting bomb-making material across the U.S.-Canadian border (FBI, 1999:9). Border guards discovered the terrorist during the normal execution of their duties. The guards became suspicious of the individual and acted in an appropriate manner to investigate their suspicions; thus, the daily execution of their jobs resulted in the passive prevention of a terrorist attack.

"America's critical infrastructure encompasses a large number of sectors[:]" agriculture, food, water, public health, emergency services, government, defense industrial base, information and telecommunications, energy, transportation, banking and finance, chemical industry, and postal and shipping (Office of Homeland Security, 2002:30). The non-interrupted functioning of this infrastructure is considered critical to the defense, economy, and public health and safety of America. Prevention measures typically taken to protect the critical infrastructure include actions to deter, deflect, and/or mitigate the effects of a terrorist attack (Office of Homeland Security, 2002:29-30). "For example, the Department of Defense has flown more than 22,000 combat air patrol missions within the United States since September 11 to protect our critical infrastructure from air attacks" (Office of Homeland Security, 2002:A-2).

Finally, the need to defend against catastrophic terrorism was clearly demonstrated by the events of September 11th; however, this critical area goes beyond the threat of conventional mass casualty. The threat posed by terrorists potentially acquiring and using CBRN technology dictates that the U.S. reconsider its approach to catastrophic acts to ensure the safety of the American people (Office of Homeland Security, 2002:37-38). The anthrax attacks on the U.S. eastern seaboard in late 2001 highlighted the need for the U.S. to have an active anti-CBRN program. Recent actions by the U.S. in this area include the acquisition of 200 million smallpox vaccines and expansion of the National Pharmaceutical Stockpile (Office of Homeland Security, 2002:A-3).

Determining the effectiveness of preventive actions can be very difficult. Therefore, detailed assessments of the terrorist threat and the nation's vulnerabilities are one of the best ways of ensuring that preventative actions have a chance of directing

terrorist attacks away from an individual target: person(s), building, infrastructure, or equipment (Office of Homeland Security, 2002:16-17). However, even when these actions are successful, preventive (or defensive) actions are only effective as mitigating factors over the short-term.

> The struggle against terrorism, however, is never-ending. Terrorism has existed for 2,000 years and owes its survival to an ability to adapt and adjust to challenges and countermeasures and to continue to identify and exploit its opponent's vulnerability. (Hoffman, 2002:314)

The Irish Republican Army (IRA) is a classic example of this never-ending cycle; over the last 20 years, they have perfected their bomb-making skill. Each time the United Kingdom develops a technology to counter the IRA's most recent bombing technologies; the IRA develops a new bombing technology or technique (Hoffman, 1998:180-183).

2.3.1.2 Proactive Action. Proactive action is overt and covert intelligence-driven actions designed to actively interdict known terrorist organizations and known terrorist actions (Veness, 2001:414). Proactive actions deliberately act on specific knowledge in order to intercept an attack, to reduce a terrorist's offensive capability, and/or to incapacitate a terrorist group. Of the six critical mission areas identified by the OHS, intelligence and warning and domestic counterterrorism are considered to involve proactive actions (Office of Homeland Security, 2002:viii-ix).

Intelligence and warning is the foundation of proactive counterterrorism operations. The element of surprise is critical to the overall success of a terrorist attack, as with any form of human conflict (Office of Homeland Security, 2002:15). This was proven on September 11th when terrorists successfully commandeered multiple commercial aircraft as part of a well-coordinated and simultaneous terrorist attack.

Controlling the element of surprise was so important during the Cold War that the U.S. spent billions of dollars in early warning systems to detect the launch of nuclear weapons (Office of Homeland Security, 2002:15). However, the shadowy nature of terrorism makes it far more difficult to detect future terrorist actions than the legitimate actions of nation states (Office of Homeland Security, 2002:15).

The responsibility for domestic counterterrorism belongs to federal, state, and local law enforcement agencies. The attacks on September 11th highlighted the need for law enforcement agencies to place a higher priority on both passive and active interdiction of terrorist activities. To improve the domestic counterterrorism capabilities of U.S. law enforcement agencies, efforts are underway to significantly improve communications between intelligence agencies and law enforcement agencies at all levels: international, federal, state, and local (Office of Homeland Security, 2002:25-26). The events of September 11th initiated the largest criminal investigation in U.S. history. This investigation, conducted by U.S. law enforcement agencies with the cooperation of the international community, resulted in the freezing of over $112 million in terrorist assets and those who support terrorism and the arrest of over 3,000 suspected terrorists (Bush, 2003:1; Office of Homeland Security, 2002:28 and A-1).

While domestic counterterrorism belongs primarily to the law enforcement community, U.S. counterterrorism efforts outside the United States include various options: U.S. or international military, international law enforcement community, or the U.S. or international intelligence services (Department of State, 2002:vii-xiii). In fact, one of the most significant impacts of September 11th has been the international coalition against terrorism orchestrated by the Department of State. This coalition includes

support from 160 nations that have joined the U.S. in identifying and stopping terrorists (Office of Homeland Security, 2002:A-1). In order for proactive action to work, experts on the subject agree on the importance of gathering good intelligence, especially good human intelligence, on the activities and motivations of terrorists (Hoffman, 1998:211; Office of Homeland Security, 2002:15-16; Veness, 2001:414-415). Once a nation knows who the enemy is, recognizes the threat they pose, and understands how they make decisions, it can take proactive steps to actively interdict the terrorist threat.

2.3.1.3 Post-Event Investigation. Post-event investigation includes the collection of evidence to identify and convict those responsible for the terrorist action (Veness, 2001:414). Of the six critical mission areas identified by the OHS, domestic counterterrorism and emergency preparedness are considered to involve post-event investigative actions (Office of Homeland Security, 2002:viii-ix). Post-event investigation, by definition, cannot stop the current terrorist attack at hand; however, post-event investigation limits collateral damage from the attack by securing the scene of the attack, identifying the terrorists responsible for the attack, providing evidence for the criminal prosecution of those responsible, and/or preventing future attacks through lessons learned.

U.S. law enforcement officials are part of a larger group of "first responders," which also includes fire and emergency services personnel, who respond to the scene of a crime or disaster (Office of Homeland Security, 2002:A-2). "America's first line of defense in the aftermath of any terrorist attack is its first responder community" (Office of Homeland Security, 2002:41). Emergency preparedness increases the quickness and efficiency of first responders and other government follow-on emergency personnel,

which can make a significant difference in mitigating the damage caused by terrorist attacks (Office of Homeland Security, 2002:41). A prime example of this is the actions of the New York City firefighters and policemen to evacuate the World Trade Center prior to and during the collapse of towers one and two on September 11th, significantly reducing the total number of fatalities from the attacks. Since September 11th, Congress has appropriated $650 million to support state and local first responders for specialized terrorism preparedness (Office of Homeland Security, 2002:A-2).

Besides identifying the parties responsible for an attack, post-event investigations also help identify flaws in counterterrorism measures. This was observed at the start of modern counterterrorism, the 1972 terrorist attack on the Munich Olympics, when lessons learned from this event demonstrated the need for specialized counterterrorism teams (Hoffman, 1998:72-73). It can also be seen in the earlier example of the evolution of IRA bomb-making expertise in response to Britain's improved counterterrorism efforts (Hoffman, 1998:180-183).

During the discovery phase of post-event investigation, many future terrorist attacks have been discovered and prevented by information that was uncovered during the investigation. A key example of this, which sent shockwaves through the counterterrorism community, was evidence acquired during the investigation of Aum Shinrikyo after the 1995 sarin gas attack on the Tokyo subway system. During raids on Aum Shinrikyo facilities, authorities found enough sarin gas to kill an estimated 4.2 million people. In addition, it was discovered that Aum Shinrikyo had produced or had plans to produce other chemical weapons (including mustard gas, sodium cyanide, VX, tabun, and soman) as well as biological weapons (including anthrax, Q-fever, and Ebola)

(Hoffman, 1998:125). All of these weapons are potentially very deadly WMD assets that could cause significant harm and damage to a society. However, post-event investigations for terrorist acts are routinely crossing the traditional lines of government and require cooperation across all levels: local, state, federal, and international (Office of Homeland Security, 2002:A-1).

2.3.2 National and International Cooperation on Counterterrorism. The ability of modern terrorists to transit local, state/provincial, and national borders while planning, training, staging, and executing their terrorist activities requires governments at all levels to cooperate in order to stem the tide of terrorism (Office of Homeland Security, 2002:1-2,59). The development of national and international governmental cooperation resulted from the evolution of terrorism and counterterrorism (Veness, 2001:412-413). This study examines cooperation on two distinct levels: national and international.

2.3.2.1 National Level. The U.S., as with most developed nations, addresses acts of domestic terrorism and international terrorist attacks within their own borders as criminal activity (Veness, 2001:413). The national vision for law with respect to Homeland Security is stated as, "We are a nation built on the rule of law, and we will utilize our laws to win the war on terrorism while protecting our civil liberties" (Office of Homeland Security, 2002:48). The treatment of terrorism as a crime creates some unique challenges and significant benefits for governments, especially modern Western democracies. The major challenges are maintaining political will, better understanding the amorphous nature of terrorist organizations, and streamlining the government bureaucracy. The major benefit is the erosion of terrorism support structures.

2.3.2.1.1 Political Will. In any democratic society, political will is the heart and soul of government. Prior to September 11th, the political will within the U.S. government resisted establishing new laws that increased the government's ability to fight terrorism at the expense of individuals' personal freedoms. As of 1999, there were various Executive Orders, Presidential Decision Directives, and Congressional statutes addressing the issue of terrorism; however, there was not a single federal law specifically making terrorism a crime. Instead, the national political will wanted to address terrorism within the existing U.S. legal framework (FBI, 1999:i). However, since the September 11th attacks in 2001, the U.S. government and its citizens have developed both a more profound understanding of the threat posed by terrorism and a stronger political will towards combating it. This has resulted in sweeping changes to the U.S. government and how it approaches terrorism (Office of Homeland Security, 2002:1). The 2003 State of the Union address by President Bush exemplifies this commitment to an extended political will towards terrorism.

> Our war against terror is a contest of will in which perseverance is power. In the ruins of two towers, at the western wall of the Pentagon, on a field in Pennsylvania, this nation made a pledge, and we renew that pledge tonight: Whatever the duration of this struggle, and whatever the difficulties, we will not permit the triumph of violence in the affairs of men -- free people will set the course of history. (Bush, 2003:2)

The major question regarding political will is the appropriate balance between personal freedoms and new laws to help U.S. counterterrorism operations (Office of Homeland Security, 2002:48).

2.3.2.1.2 Amorphous Nature of Terrorism. The amorphous nature of modern terrorist organizations challenges the U.S. because the evidentiary ties between

the organization and its members are not clearly defined. This makes it more difficult for the government to prosecute the organization for the actions of individual members. Primarily, there are two types of amorphous terrorist groups: part-time terrorist groups and full-time or regular terrorist organizations. Part-time terrorist groups are loose organizations of like-minded individuals willing to utilize violence to change a perceived problem with the current society; these groups are normally considered to be domestic terrorists. The majority of U.S. domestic terrorism reported by the FBI in their annual reports falls into this category. Hoffman (1998) cites the Oklahoma City bombing by Timothy McVeigh as an example of this type of terrorism by highlighting the ties between McVeigh and the Michigan Militia, which is classified as part of the larger American Christian Patriot movement. However, only McVeigh and his partner were tried and convicted for the Oklahoma City attack (Hoffman, 1998:105-107).

The second form of amorphous terrorist groups are traditional terrorist groups who have realized that there is an inherent benefit to keeping a low profile. Al Qaeda's adoption of this policy has been cited as one reason for their success to date (Hoffman, 2002:306-307). Al Qaeda even established organizational rules to make it more difficult for governments to legally prove their involvement in terrorist actions (Gunaratna, 2002:35).

2.3.2.1.3 Bureaucracy. Bureaucracy is a primary concern in the effectiveness of any governmental organization, especially in a democracy, because it has a tendency to hinder interagency cooperation. Although the threat of terrorism is not likely to change the actual process of government established by the Constitution, the effects of multiple actors inside and outside the government will continue to make public

policy on terrorism a compromise between opposing positions and opposing agendas (Crenshaw, 2001:335). Therefore, to maximize the U.S. government's organizational efficiency in the fight against terrorism, the White House developed the National Strategy for Homeland Security and established the Department of Homeland Security (Office of Homeland Security, 2002:vii-xiii).

2.3.2.1.4 Erosion of Terrorist Support. The major benefit of criminalizing terrorism comes from the fact that "terrorism is fundamentally a form of psychological warfare" (Hoffman, 2002:313). If the government effectively produces an environment in which terrorism is socially unacceptable, the government can establish a media campaign that minimizes the attention, sympathy, and moral support that many terrorist organizations seek in order to maintain their support structures (Veness, 2001:413). Since the cardinal rule of conflict is to "know your enemy" (Hoffman, 2002:306), it is important to consider what the targeted terrorist group is trying to accomplish and understand their underlying motivation.

> All terrorists, however, have one trait in common: they live in the future, live for the distant – yet imperceptibly close – point in time when they will assuredly triumph over their enemies and attain the ultimate realization of their political destiny. For the religious groups, this future is divinely decreed and the terrorists themselves specifically anointed to achieve it. (Hoffman, 1998:169)

Understanding motivations is particularly critical when dealing with secular terrorists; who are much more dependent on the level of moral support from the national and international community. Therefore, the criminalization of terrorism can be an effective tool for managing the acceptable level of damage a terrorist can inflict during their attacks while still maintaining an adequate support base. This was illustrated with the

earlier discussion of the Real IRA bombing at Omagh (Dingley, 2001:451, 460-463; Quillen, 2002a:281).

2.3.2.2 International Level. The international level describes the multinational cooperation required to fight the growing threat of international terrorist organizations. Perhaps the best example of this has been the continuing multinational coalition of over 160 nations established by the U.S. after the September 11th attacks (Office of Homeland Security, 2002:A-1). According to U.S. Ambassador Taylor, the State Department Coordinator for Counterterroism, "The events of 9/11 galvanized civilized nations as no other event has; ironically, by their own hand, terrorists set in motion their own ultimate demise" (Department of State, 2002:v). In stark contrast to previous efforts to collectively fight terrorism, the global community has come together primarily because of the unimaginable brutality of the September 11th attacks. For 2 years following the 1972 Palestinian attack at the Munich Olympics, the U.N. held several conferences trying to condemn terrorism; however, the Western nations and many third world nations could not agree on the definition of terrorism (Hoffman, 1998:31-32). Since September 11th, 2001, the U.N. has again focused its international discussions on the problem of terrorism. Additionally, the U.N. established the Counter Terrorism Committee to monitor the implementation of U.N. Resolution 1373, which requires nations to report how they are fighting terrorism in seven major areas: legislation, finance, customs, immigration, extradition, law enforcement, and arms traffic. The U.N. General Assembly has also adopted 12 conventions on terrorism (Department of State, 2002:155). However, the problem that plagued initial U.N. attempts to define and control terrorism is still present today. Many of the smaller nations that condemned the September 11th

attacks still claim that terrorism is the only way for many smaller or weaker groups, and nations, to fight larger and/or more powerful governments. For instance, many Arab nations, e.g., Iran, Lebanon, Syria, etc., rely on terrorism to fight Israel (Department of State, 2002:57,65, and 68).

The U.S. decided not to wait on action from the U.N. following the September 11th attacks and led the creation of an international coalition against terrorism. While most countries consider terrorism to be illegal, they often approach terrorism, especially terrorism outside their borders, with a military response against terrorist groups and their state sponsors. However, there is some evidence that military strikes against terrorism can actually increase support and credibility to the terrorist organization from within the group's constituent populations (Hoffman, 1998:192-193). Therefore, the criminalization of terrorism has produced effective ways to fight terrorist organizations without creating as much sympathy for terrorist groups (Veness, 2001:413). The criminalization of terrorism has also created common ground for international relations on terrorism and for the extradition of terrorists to stand trial for their crimes (Department of State, 2002:155-160). Additionally, since terrorism is a war of public psychology (Hoffman, 1998:154-155; Hoffman, 2002:313), criminalizing terrorism gives the government an edge in the media battle (Veness, 2001:413).

2.4 System Dynamics

As identified in Chapter I, system dynamics is an interdisciplinary methodology that uses "the theory of nonlinear dynamics and feedback control" to evaluate complex behavioral patterns (Sterman, 2000:2-4). While most modern system dynamics modeling

efforts capitalize on more visually based modeling techniques, the heart of the methodology comes from the use of non-linear differential equations to represent known types of natural behavior: oscillation, first order growth or decay, etc. Because system dynamics is interdisciplinary, it has been applied to many different dynamic systems, both natural and man-made, ranging from "physics to physiology and psychology, from the arms race to the war on drugs, from global climate change to organizational change" (Sterman, 2000:901). Although the methodology has not been used in the study of terrorism, the literature contains examples that illustrate the potential use of the system dynamics approach to study the dynamic system of terrorism-government interaction. In particular, the ability of system dynamics to explain an organization's behavior and investigate its interactions with its situational environment makes this methodology ideal for the current research effort.

Because system dynamics can be used to study complex systems comprised of natural and/or man-made behaviors, it helps organizational leaders understand underlying system interactions (Wolestenholme, 1999; Barlas, Çirak, and Duman, 2000; Ritchie-Dunham and Galván, 1999; and Barjrachrya, Ogunlana, and Bach, 2000). For the purpose of this study these underlying system interactions will be divided into two types: those that drive the organization and/or those that drive the situational environment in which the organization operates. For the propose of this study, an organizational system is defined as a complex system of man-made and/or natural interactions that occur within the organization and that are controlled in part or full by the organizational policies implemented by the organizational leadership. Similarly, a situational system is defined as the complex system of man-made and natural interactions that occur outside the

organization and where control policies provided by the organizational leadership provide limited control of these situational behaviors. For this research, the set of complex interactions within either the terrorist or government organization are considered organizational systems, and the interactions between terrorist and government organizations are more appropriately described as the situational system. Therefore, the purpose of this study is to explore the underlying interactions between governments and terrorist organizations that drive the system.

Because the overarching terrorist-government system interactions are between two smaller competing systems, a significant portion of the overall system behavior can be explained by the situational system behavior imposed by one of the smaller systems on the other. This observation is supported by the evolution of terrorism over the last half century; however, the following discussion is offered to further illustrate this point.

> Terrorism is perhaps best viewed as the archetypal shark in the water. It must constantly move forward to survive and indeed succeed. Although survival entails obviating the government countermeasures designed to unearth and destroy the terrorists and their organization, success is dependent on overcoming the defenses and physical security barriers designed to thwart attack. In these respects, the necessity for change in order to stay one step ahead of the counterterrorism curve compels terrorists to change—adjusting and adapting their tactics, modus operandi, and sometimes even their weapons systems as needed. (Hoffman, 2002:313)

By addressing the forces of change that cause the overall situational environment to change in favor of one of the two organizational systems, government or terrorist, one can develop a better understanding of the overarching system. By understanding the underlying behaviors which drive how terrorist organizations and the government interact with each other, it is possible for the government to tailor their response to terrorist

actions in a way that will mitigate long-term and short-term terrorist activity and dampen the overall public threat of terrorism.

As previously stated, system dynamics has not been applied to terrorism; however, it has been applied to human conflict, a type of situational behavior between two opposing systems Although the study of conflict is not a major topic within the system dynamics literature, there are two examples (Wils, Kamilya, and Choucri: 1998; Coyle and Alexander: 1997) that demonstrate how it can be applied to the complex system of human interaction, including conflicts between individuals, organizations, and nations. Wils, Kamilya, and Choucri (1998) studied the effects of regional security and stability on the environmental construct of sustainable development, which is simply an evaluation of society's capability to live off their environmental surroundings in a way that does not produce a net degradation of the overall natural resources for that area. The argument of Wils, Kamilya, and Choucri (1998) is that there is a direct link between the level of security and stability a nation or region enjoys and their ability to establish and maintain a sustainable level of development for their society. They base this argument on the fact that the same underlying parameters affect both constructs; therefore, if resources are being utilized to maintain security, then they are not being used to establish and maintain sustainable development. They further argue that countries that do not have the resources they require to sustain their development will place pressure on the suppliers of those resources to maintain the security of their nation. Wils, Kamilya, and Choucri (1998) observe that the tension developed by a resource constraint has both an internal and external component. They further distinguish the external pressure component as a "lateral pressure" (Wils, Kamilya, and Choucri, 1998:131).

The Wils, Kamilya, and Choucri (1998) study formulates each of these internal and external pressures as a function of population, technology, and resources over time. After developing these relationships, they simulated the "lateral pressure" for different countries around the world. From these simulations, they inferred that if the U.S. and Europe maintain their current course, they will have to become more involved militarily around the world to ensure their security and stability. They also inferred the types of changes that could be made, like reducing military spending and reducing resource consumption rates, to correct this trend and provide greater sustainability in overall world development (Wils, Kamilya, and Choucri, 1998:153-154).

Besides using system dynamics to evaluate the underlying causes for human conflict, system dynamics can also be used to model the overall situational environment. Coyle and Alexander (1997) used a hypothetical drug-trade model to demonstrate the potential advantages of the system dynamics approach to military planning and the evaluation of complex situational systems involving human conflict between a government and hostile organizations. Since Coyle and Alexander (1997) use a hypothetical approach to model the problem, they stop developing the system dynamics model at the influence diagram, which is step two of the 5-step system dynamics process described in Chapter III. Instead of continuing with traditional systems dynamics, they conduct a qualitative analysis of the influence diagram at several different levels of aggregation to provide general insight into the overall system being studied. The theory is that this deeper level of understanding by the researcher and/or the customer, in this case the military planner, will assist them in doing a better job since they now have a better understanding of their situational environment (Coyle and Alexander, 1997:205-

207). As demonstrated by Coyle and Alexander (1997), a qualitative model that does not reach the full capacity to simulate system interactions due to a lack of reliable data can still provide individuals much needed insight into the situational environment (Coyle and Alexander, 1997:206-207, and 213). Like the drug trade, terrorism is a relatively new construct for government planners, both military and civilian; thus, any tools that can help them better understand the overall situational environment and the underlying causes of their conflict give the government a much need advantage in the "war on terror."

III. Methodology

3.1 Systems Dynamics Overview

System dynamics was selected as the research methodology for this study because of its ability to model behavior patterns of complex man-made and natural systems (Sterman, 2000:4-5). The methodology iteratively adds layers of complexity on top of the most simplistic view of the overall system until the appropriate level of aggregation is reached to address the question at hand (Sterman, 2000:87-88). Therefore, this research used system dynamics as a tool to develop a model that portrays the basic behaviors of the terrorist-government system and provides insight into some of the inherent interactions. System dynamics models these interactions by representing the "connections between the variables involved as a system of first-order (usually non-linear) differential equations" (Barton and Tobias, 1998:85). The computer software used for model simulations in this research was Stella® version 6.0 from High Performance Systems (HPS), Inc., 2000. Stella® 6.0 utilizes graphical representations of stocks, flows, converters, and connectors as the basic building blocks for the model simulation (HPS, 1997:3-1).

Since terrorism is a relatively new field of study, a customer or system expert was not available to participate in this research. Therefore, this research used an inductive study similar to the one conducted by Coyle and Alexander (1997) and utilized an iterative model-building approach consisting of five basic steps: problem articulation, formulation of a dynamic hypothesis, formulation of a simulation model, testing, and policy design and evaluation (Sterman, 2000:86). Using these five steps, a very basic

model of the system was hypothesized and constructed. Additional detail was iteratively added to the model until an acceptable level of detail was reached to meet the objectives of this study. This iterative approach increases the overall confidence in the model and allows other researchers to duplicate this research in an effort to progressively study this complex system.

3.2 System Dynamics Step 1: Problem Articulation (Boundary Selection)

In step one, the researcher defines the problem, key behaviors, and reference mode (Sterman, 2000: 89-91). The reference mode is a graphical illustration of how the system behaves over time (Shelly, 2000:38; Sterman, 2000:91) and is the basis for the development of the dynamic hypothesis in step 2 (Sterman, 2000:94-95). To illustrate the fundamental concepts of system dynamics, a model of an individual's retirement plan will be used, which is unintentionally similar to the finance example from HPS (1997). As with any retirement plan, the assumption is that a set amount of money will be invested each month and that it will grow at some estimated rate. The reference mode, which represents the expected behavior of the system, for such a retirement plan is shown in Figure 3. In system dynamics, the actual values associated with the system's behavior is not as important as the type and magnitude of the expected behavior (Shelly, 2002:64). For this example, one would expect first-order growth based on the interest rate.

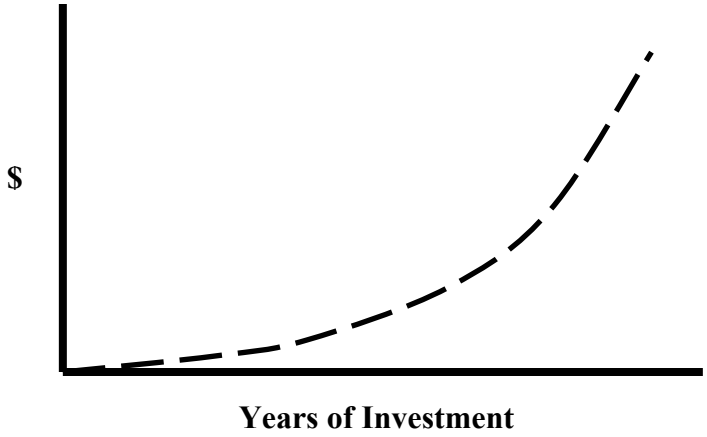


Figure 3. Sample Reference Mode for Retirement Plan

3.3 System Dynamics Step 2: Formulation of a Dynamic Hypothesis

In step two, the researcher identifies the endogenous variables and exogenous parameters required to create a causal loop diagram, or influence diagram, based on the reference mode (Sterman, 2000:94-102). Endogenous variables are the model entities that represent internal system forces. Exogenous parameters are the basic model assumptions about outside forces affecting the system. Within the system dynamics field of study, it has been established that certain system structures (as represented by influence diagrams) correspond to a set of basic behavioral patterns over time (Sterman, 2000:107).

Continuing with the retirement plan example, the system dynamics structure for first-order, or exponential, growth is a reinforcing loop developed by positive feedback as shown in Figure 4 (Shelly, 2002:53; Sterman, 2000:108-109). Positive signs indicate a reinforcing relationship between the endogenous variables, and negative signs indicate a compensating or balancing relationship between variables. If the sum of the signs in a

loop is positive, it is called a reinforcing loop that provides positive feedback and makes the system behavior unstable. If the sum is negative, then it is a compensating loop that provides negative feedback and makes the system behavior stable (Shelly, 2002:48; Sterman, 200:142-147). A lone reinforcing loop promotes uncontrolled growth or decay, which indicates an unstable system; similarly, a lone compensating loop provides a dampening affect on growth or decay, thereby causing a stable system that reaches a steady-state condition (Sterman, 2000:108-111; Shelley, 2002:48).

Using this basic understanding of system dynamics, the first-order growth for the retirement plan is expected to be caused by a single reinforcing loop. For this example, there are three identified endogenous variables: monthly investment increase, invested amount, and return on investment. There are also has two exogenous parameters: monthly investment and the interest rate. The magnitude of the increase in the investment account is a factor of the monthly investment and the amount of interest earned over the past month (represented by return on investment). This produces the influence diagram shown in Figure 4.

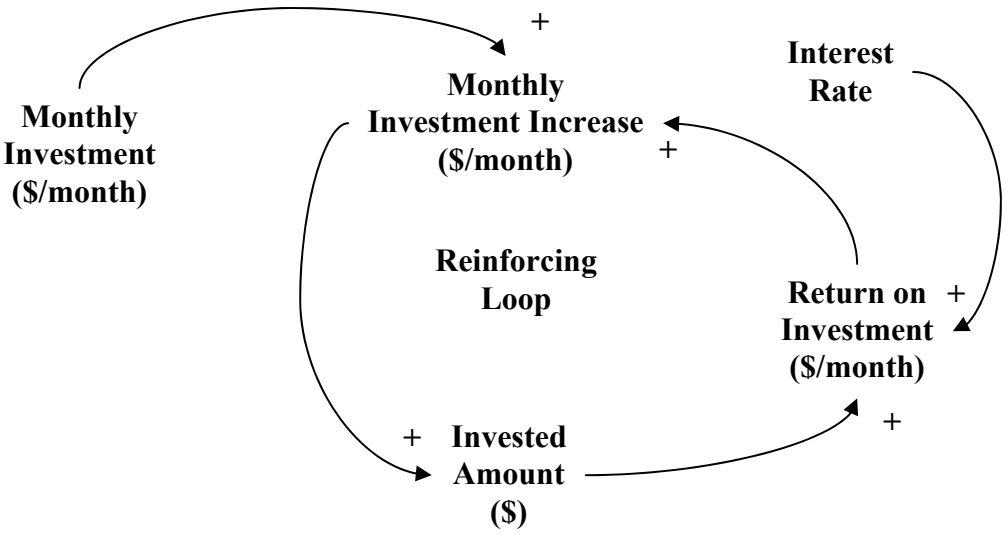


Figure 4. Sample Influence Diagram for Retirement Plan

3.4 System Dynamics Step 3: Formulation of a Simulation Model

In step three, the researcher transforms the influence diagram into an appropriate flow diagram and enters the model into a computer simulation program. Key to this portion of the process is the definition of variables, test parameters, initial conditions, and the decision rules (Sterman, 2000:102-103). Additionally, a primary source of confidence in the system dynamics methodology is the iterative process. Therefore, each time an endogenous variable is added to the influence diagram, a new simulation model is developed. As variables are added, they are referenced to other endogenous or exogenous model parameters. This iterative process helps ensure that the definitions of the variables are accurate and defendable.

Since Stella® uses a system of stocks and flows, the variables must be defined as stocks, flows, or converters. A stock is any variable that accumulates, or is stockpiled,

over time; a flow is the movement either into or out of the stock at a given rate over time; and a converter is a variable that modifies the flow of information between variables identified as stocks or flows (HPS, 1997:3-14). For this example, the stock is the "Invested Amount," the flow is the "Monthly Investment Increase," and the converter is "Return on Investment." The converter is also considered an information node because it represents the increase in the inflow rate of "Monthly Investment Increase" caused by multiplying the magnitude of the stock, "Invested Amount," by the exogenous variable, "Interest Rate." In Stella®, stocks are represented by rectangles; flows are represented by plumbing valves; and information nodes and exogenous parameters are represented by small circles. Thus, the corresponding model is shown in Figure 5.

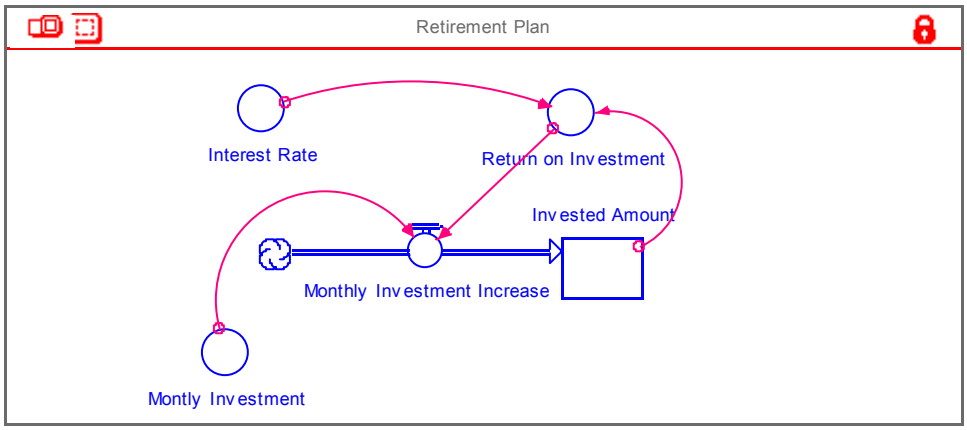


Figure 5. Stella® Model for Retirement Plan

3.5 System Dynamics Step 4: Testing

To validate and verify system dynamics models, Sterman (2000:845-891) describes the 12 tests shown in Table 2. Many of these tests involve reviewing the model

output, which is shown in Figure 6 for the retirement plan. Because of the simplicity of this example, some of these tests are not applicable to the example; however, all but the last one will be included in the following discussion.

Table 2. 12 Tests for System Dynamics (Sterman, 2000:859-861)

Test	Location	Question
Boundary Adequacy	3.5.1	Does the boundary of the model encompass the important concepts? Does a change in the boundary significantly change the modeled behavior?
Structure Assessment	3.5.2	Is the model structure consistent with the system? Is the model properly aggregated? Does the model violate any known laws of reality?
Dimensional Consistency	3.5.3	Do the dimensions on the right-hand side of the variable equations match the dimensions on the left-hand side?
Parameter Assessment	3.5.4	Are the parameters consistent with the real world knowledge of the system?
Extreme Conditions	3.5.5	Does the model crash when extreme values are used for the model parameters?
Integration Error	3.5.6	Is the modeled behavior sensitive to a reduction in the time interval by half?
Behavior Reproduction	3.5.7	Does the model reproduce the behavior that is observed in reality? Do the frequency and phase of the model match the real system?
Behavior Anomaly	3.5.8	Do changes in the model assumptions produce anomalies in the model behavior?
Family Member	3.5.9	Does the model produce behavior that is consistent with similar systems to the one being studied?
Surprise Behavior	3.5.10	Does the model account for previously unobserved behavior or novel system conditions?
Sensitivity Analysis	3.5.11	Is the model sensitive to numerical, behavioral, or policy changes in the model settings?
System Improvement	Not used in this study.	"Did the modeling process help change the system for the better?"

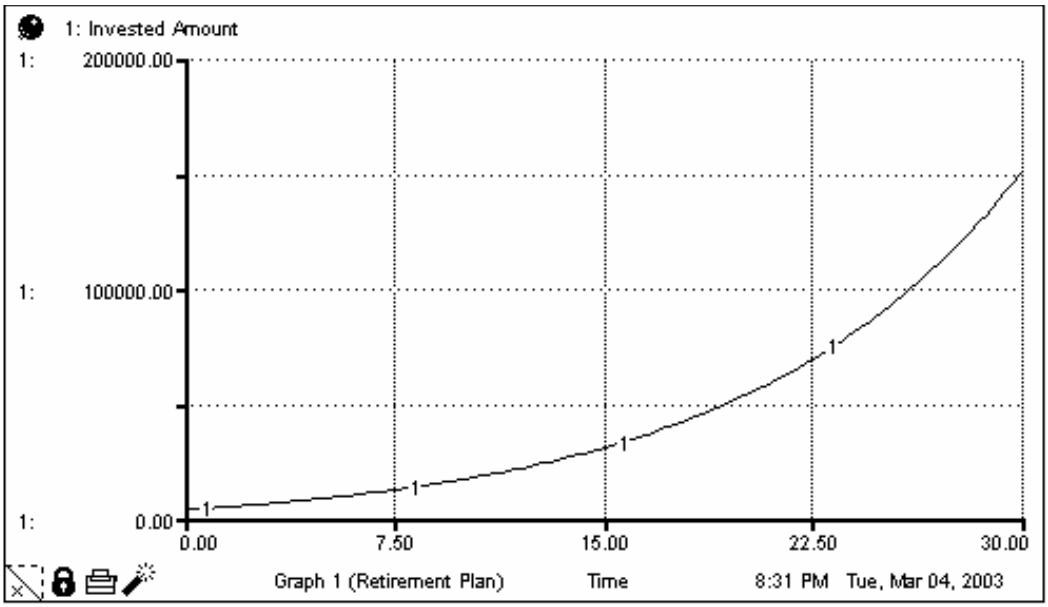


Figure 6. Model Response for Retirement Plan

3.5.1 Boundary Adequacy. For this test, the researcher defines the boundary of the current model and determines if it is appropriate for the research question. The boundary is where the endogenous model variables stop and exogenous model parameters begin. When a model variable is established as a constant, it is actually an exogenous model parameter. Therefore, this test relies on the judgment of the researcher and the customer to determine the level of detail required for the boundary. If the research team determines that a key model feedback mechanism is not included within the model boundary, then the boundary must be reset (Sterman, 2000:861-862). For the retirement plan example, the current model boundary is shown by the dotted line in Figure 7; note that the boundary includes the endogenous variables identified earlier.

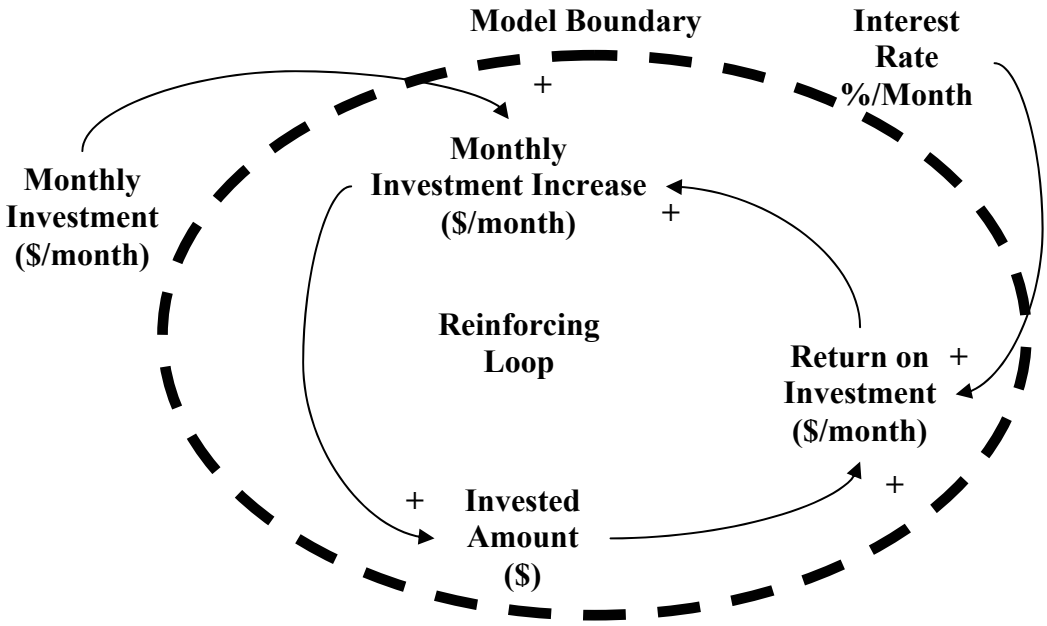


Figure 7. Model Boundary for Retirement Plan

3.5.2 Structure Assessment. The structure assessment test, similar to the boundary adequacy test, addresses the required level of detail for the model. However, it compares the actual model structure with reality to determine if the model violates any "real world" laws or rules, such as the laws of physics or negative modeling numbers for things that cannot be negative in reality (e.g., "water flowing uphill") (Sterman, 2000:863-864). For the retirement plan example, the model structure follows what is found in the real world.

3.5.3 Dimensional Consistency. "Dimensional consistency is one of the most basic tests and should be among the first you do" (Sterman, 2000:866). Dimensional

consistency addresses the question, "Do the units of measure on the left-hand side of the mathematical equation match the units of measure on the right hand side of the equation?" If the units do not correspond, the equation is not valid. For the retirement plan example, a quick mathematical check shows the model maintains dimensional consistency.

3.5.4 Parameter Assessment. A key factor in the success of any modeling effort is the proper delineation of model parameters. Because system dynamics models behaviors, traditional statistical assessment of some parameters may not be possible.

> "In practice, statistical and judgmental methods are used together. Knowledge of the real system constrains the plausible range for many parameters; statistical estimation provides a check on the judgmental estimates." (Sterman, 2000:867)

For the retirement plan example, the parameters could be debated but are effective for the purposes of the model. An example of a non-plausible parameter is a fixed interest rate for a retirement investment account over 30 years. An individual can get a fixed interest rate for this period of time when borrowing money, but most investment accounts have variable interest rates over long periods of time.

3.5.5 Extreme Conditions. In its most basic terms, the extreme conditions test validates that the model does not crash when it reaches either the upper or lower boundary of the model. There are two types of extreme condition tests: equation tests and simulation tests (Sterman, 2000:869). For this example, there is no upper boundary and the lower boundary is zero, so the model does not violate this test.

3.5.6 Integration Error. Because system dynamics uses first-order equations to model complex behaviors, the interval of time over which the simulation iterations are

conducted, typically referred to as delta time (DT), is an important factor of the simulation process. If a 50 percent reduction in the interval of time causes a significant change in the model, the initial time interval is considered too large. If the time interval can be reduced by 50 percent without significantly affecting the model, the time interval is considered appropriate (Sterman, 2000:872). The example passed this test.

3.5.7 Behavior Reproduction. The behavior reproduction test validates whether the model produces behavior similar to the "real world" system being studied. For systems with measurable behavior and existing or collectable data, statistical methods can be used to measure the variance of the model from the real system (Sterman; 2000: 874-880). For the retirement plan example, the model output was shown in Figure 6; as the figure shows, the model output follows the expected real-world behavior.

3.5.8 Behavior Anomaly. The behavior anomaly test validates the structure of the model by examining the system's behavior when a targeted system relationship is removed. The greater the behavior anomalies created by this targeted elimination, the more important that targeted relationship is to the model. A common method of accomplishing this is the "loop knockout analysis" technique in which each loop within the system is systematically targeted (Sterman, 2000: 880-881). The retirement plan example only has one loop, so the "loop-knockout analysis" cannot be preformed.

3.5.9 Family Member. The family member test validates the generality of the model by examining if the model can be applied to similar systems with different parameter values (Sterman, 2000:881). For the retirement plan example, the model could be applied to any investment that had a fixed rate of return over the same time period.

3.5.10 Surprise Behavior. When the model output and the research expectations based on real-world data do not match, it normally is an indicator of flaws in either the formal model diagram or the mental model. The formal model is the model being tested; the mental model is the perceived model in the minds of the researcher and the customer of the system. The surprise behavior test validates the model by demonstrating system behaviors that are not "previously recognized" but actually do occur in the natural system (Sterman, 2000:882). This is a critical point in helping researchers develop a better understanding of the overall system. The simplicity of the example does not lend itself to this test.

3.5.11 Sensitivity Analysis. All models are sensitive to changes in their assumptions. System dynamics modeling has three main types of sensitivity: numerical, behavioral, and policy. Numerical sensitivity addresses how much the model output will change based on small changes in model parameters. Behavioral sensitivity addresses changes in the behavior patterns of the model. Finally, policy sensitivity addresses the effectiveness of various system-control policies (Sterman 2000:883). As before, the simplicity of the example does not require the use of this test.

3.6 System Dynamics Step 5: Policy Design and Evaluation

The last step of the process before starting another iteration determines if all the necessary real-world conditions of the system have been modeled or if significant real-world system behaviors have been unaccounted for in the current model. It also identifies what policy controls need to be implemented by management for better control of the system. In this step, the researcher determines if the model complexity satisfies the

scope of the research endeavor or if another layer of complexity is required. If the model is acceptable and valid, the researcher identifies policy changes to help control the system. For any identified policy changes, another simulation iteration of the model is conducted. Once an acceptable and valid model is obtained with the desired policy controls in place to manage the system, the process is complete (Sterman, 2000:103-104).

For the retirement plan example, suppose the goal is to have $100,000 at the time of retirement. As the account balance nears this amount, suppose the individual decided to base the monthly deposit on a percentage of the goal attained. If that were the case, the reference mode would be an S-shaped curve that approaches steady-state at $100,000, as shown in Figure 8, instead of uncontrolled first order growth. For this S-shaped reference mode, a compensating loop with a goal-seeking structure would be added to the influence diagram as shown in Figure 9. The corresponding model output from Stella® is shown in Figure 10.

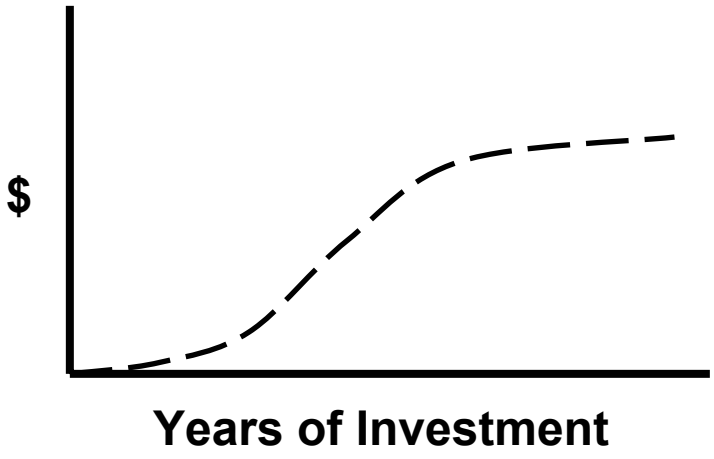


Figure 8. Revised Sample Reference Mode for Retirement Plan

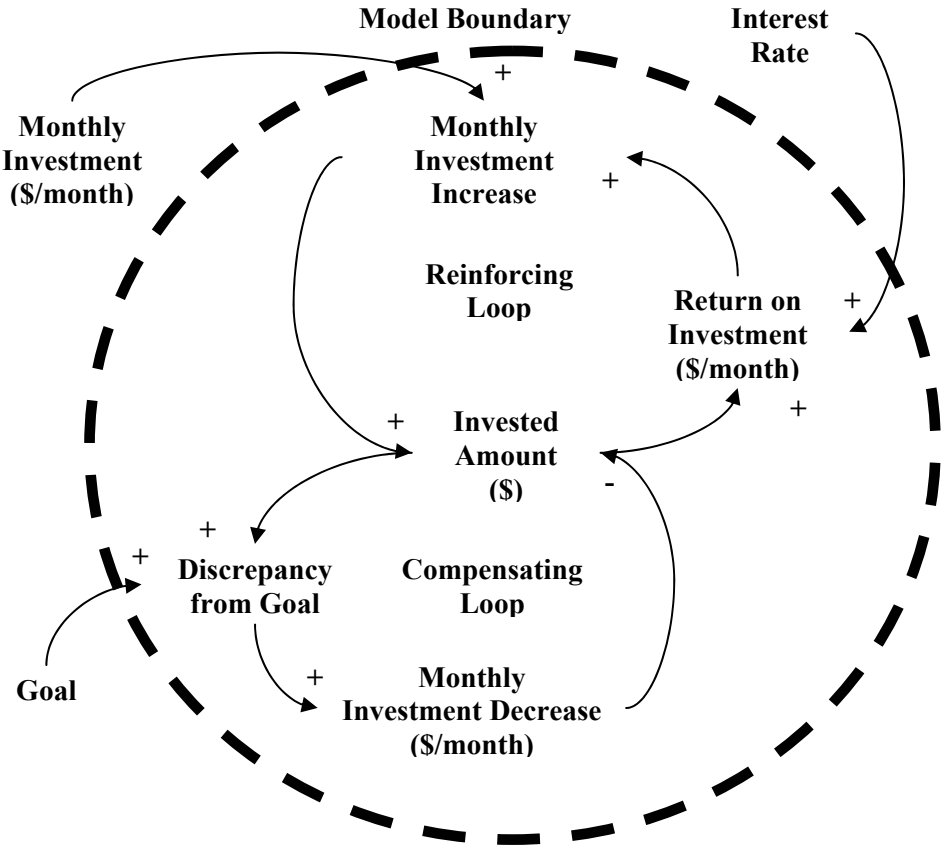


Figure 9. Revised Influence Diagram with Model Boundary for Retirement Plan

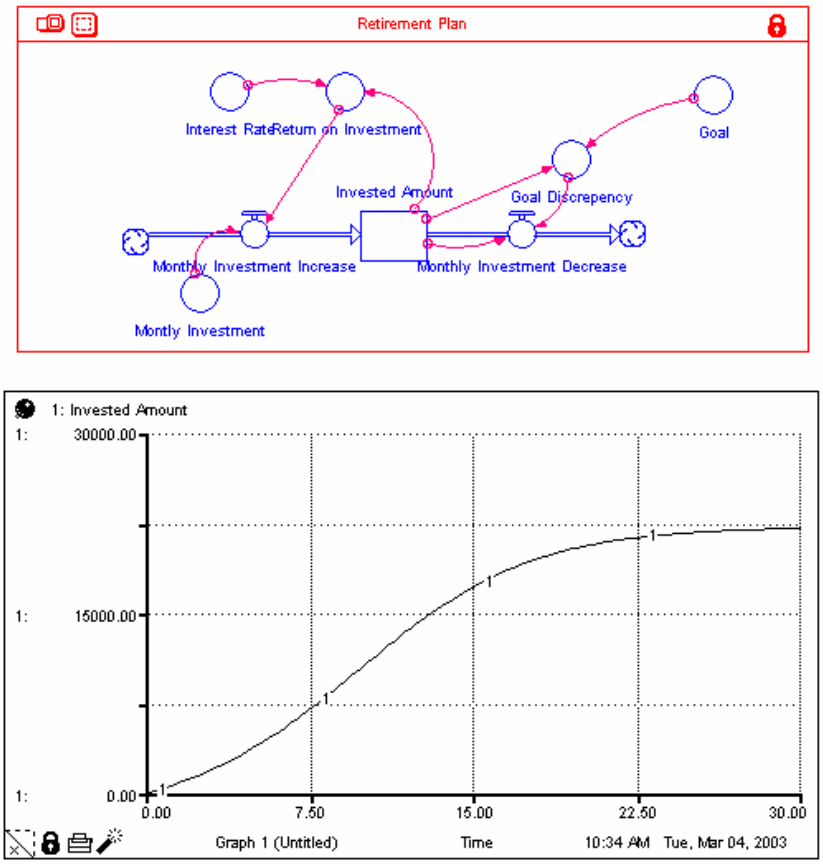


Figure 10. Revised Stella® Model and Output for Retirement Plan

3.7 Summary

Based on these examples, the expectations for Chapter IV should be clear. The model for the system of terrorist–government interactions will be developed from its most aggregated view (similar to Figure 1) to a less aggregated level that meets the objectives of the study. It is expected that the number of overall iterations will be large; however, given the unique nature of this research, it is unlikely that this effort will develop far enough along to incorporate some type of policy development as described in step 5.

IV. Results and Analysis

This study was designed to examine how the interactions between terrorist and government forces form a dynamic system of action and reaction. It was also designed to determine how the government might be able to affect the behavior of this system through various types of policy controls. To keep the scope at a manageable level, this study examines only the basic interactions of the overall system at an aggregate level. This was quantified by two objectives: (1) attempt to identify the primary interactions between terrorist organizations and the government by iteratively disaggregating the model boundary and (2) provide insight into how the system behaves.

These objectives were met by applying the iterative system dynamics methodology described in Chapter III, which resulted in five distinct modeling efforts identified as model series 1 through 5. Table 3 provides a brief description of the five modeling series and a brief summary of their basic results. This section provides discussion about these five model series and the major decision points used in the modeling process. The remainder of the chapter reviews the sensitivity analysis of selected model parameters and the impact on the overall final model.

Table 3. Summary of the Five Modeling Series

Model Series	Number of Models	Iterations	System Structure	Focus Area	Result
#1	10	2	Overshoot and Collapse	Overall Model	Abandoned for Series 2, 3 & 5
#2	3	3	Oscillation	Daily Interactions	Used in Series 5
#3	5	5	Overshoot and Collapse	Significant Event	Abandoned for Series 4
#4	11	11	Oscillation with Goal-Seeking	Significant Event	Used in Series 5
#5	4	4	Combination of 2 & 4	Overall Model	Final Model

4.1 Model Series 1.

This model series was based on the original hypothesized reference mode shown in Figure 11. This hypothesis was derived from the mental model of the system identified in Figure 1, which shows that the government reacts to the perceived actions of the terrorist group and that in turn the terrorist group reacts to the perceived actions of the government. Based on this mental model, the reference mode in Figure 11 was created as an oscillatory behavior between terrorist activity (TA) and government activity (GA). As terrorist activity increases, government activity also increases; however, there is a time lag, or phase shift in the oscillation, for the government activity. As government activity increases, the terrorist activity decreases as they attempt to evade the government's actions. The original hypothesis shown in Figure 11 assumes a sinusoidal oscillation. However, it was hypothesized that the terrorist group operated with some limited resource base. Therefore, when they attacked, the resulting depletion of the resource would cause a drastic drop in the terrorist's capability to conduct activities.

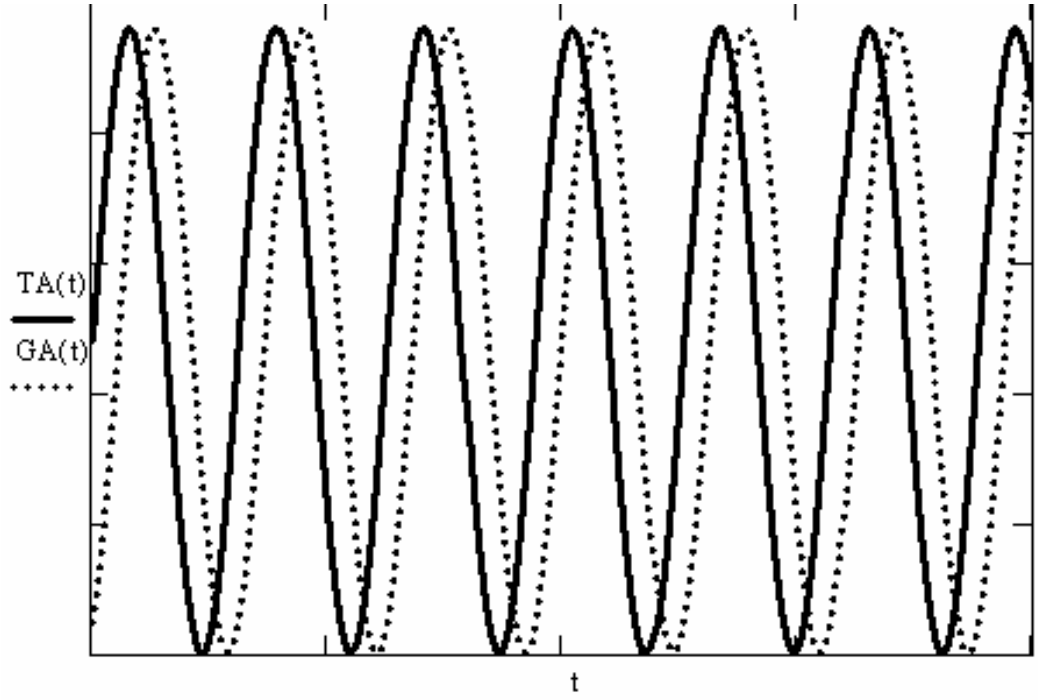


Figure 11. Hypothesized Terrorist Reference Mode
TA – Terrorist activity and GA – Government activity

Based on this revised hypothesis, an overshoot and collapse structure was selected for the associated influence diagram. The overshoot and collapse structure in system dynamics models an activity that is dependent on some secondary resource. If that supporting resource is driven to zero, then the supported activity must also be zero. A classic example would be the ability of a natural habitat to support a given animal species; if that animal consumes too much of the natural resources, then the population of the species will drop to a population level that the environment can support.

After partially developing model series 1, it was determined that the hypothesized reference mode for the model was not completely accurate. It was determined that some terrorist activities were operating independent of the supporting terrorist resources required for a significant terrorist attack. These actions were classified as the daily activities required for an organization to function properly. The realization that the terrorist side of the mental model might actually have two distinct behaviors driven by two separate sub-systems within the larger system led to a revised hypothesis for the overall reference mode. As shown in Figure 12, the revised reference mode consisted of one reference mode based on terrorist daily activity (TDA) and another based on terrorist significant events (TSE). The sum of these two behaviors drive the responding government activity (GA); therefore, a portion of the government response can be attributed to each sub-system on the terrorist side of the equation. Because of these reevaluations, model series 1 was abandoned and two separate approaches were used to determine the most appropriate reference mode and model structure.

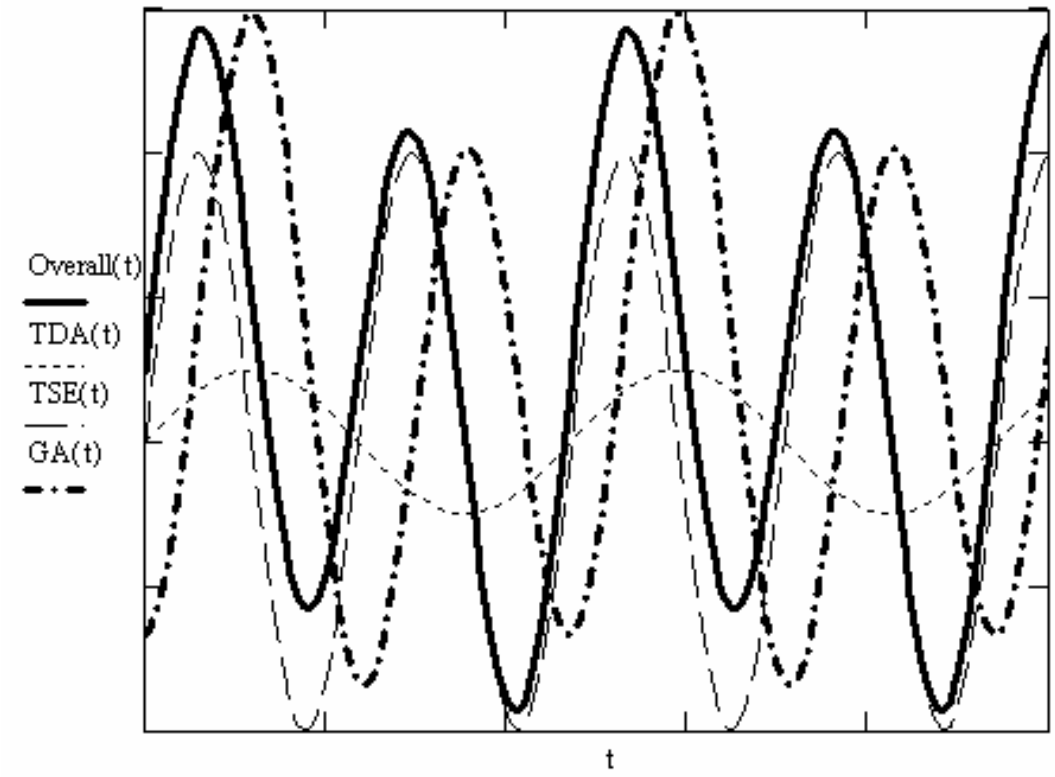


Figure 12. Revised Hypothesized Terrorist Reference Mode with Component Reference Modes

TDA – Terrorist daily activity, TSE – Terrorist Significant Event and GA – Government activity

4.2 Model Series 2.

The development of model series 2 was based on the terrorist daily activity reference mode shown in Figure 13. From the basic oscillating structure between government activity and daily terrorist activity, this series was iteratively developed in a very systematic approach. To demonstrate the iterative process used during the development of the model series, the steps used to create the models in model series 2 will be discussed. The first iterative model in this series was called model 2A. For

additional reference, the entire final model for this series, Model 2C, is included in Appendix A.

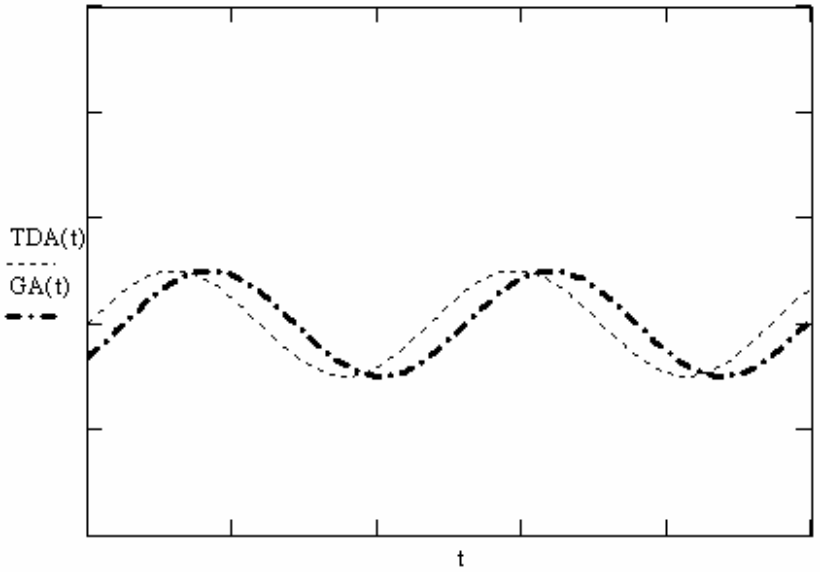


Figure 13. Model Series 2 Reference Mode
TDA –Terrorist Daily Activity and GA – Government Activity

4.2.1 Step 1. The first step in any system dynamics modeling effort is to define the reference mode, shown in Figure 13. Because the government activity is based solely on the terrorist daily activity, the resulting government activity will be similar to the terrorist daily activity; the only differences are in the magnitude of the activity and a phase shift to indicate that government activity lags terrorist activity. One of the biggest issues in developing the reference mode was determining how to measure activity; therefore, all activities were transformed to a level of daily spending in U.S. dollars. Initially, the focus was on the relative magnitudes of the dollar values rather than the

actual dollar amounts. This was based in part on the fact that it was unclear which model variables and parameters needed to be defined immediately.

4.2.2 Step 2. The next step in the system dynamics modeling effort is to determine the influence diagram required to produce the behavior shown in the reference mode. The standard influence diagram associated with oscillating behaviors consists of two stock-flow combinations in which the quantity of one stock drives the inflow of the opposite stock, and the quantity of the second stock drives the outflow of the first stock. For this model series, the respective influence diagram is shown in Figure 14. Note that the daily activities of the terrorist cause an increase in government spending, which reinforces the amount of government expenditures. As government expenditures increase, it is expected that this will cause terrorist activity and expenditures to decrease.

The endogenous variables for this initial model are the respective increase and decrease in the daily expenditures by both the terrorist group and the government. The exogenous model parameters for the initial model are growth, government effectiveness, and loss rate for the terrorist side of the model; and maintenance rate, conversion factor, and pressure for the government side of the model. The endogenous variable of terrorist spending is driven by the exogenous parameter of growth, which states that the terrorist daily expenditures will increase each day at some rate of growth. For this level of detail, the parameter of growth is assumed to be fixed. The terrorist decrease in spending is a function of the amount of terrorist expenditures lost due to organizational inefficiencies as represented by the parameter loss rate and the effectiveness of government operations against terrorist's assets as represented by the parameter government effectiveness. In

both cases, these efficiency rates are multiplied by the respective level of activity to determine that actual decrease in terrorist spending.

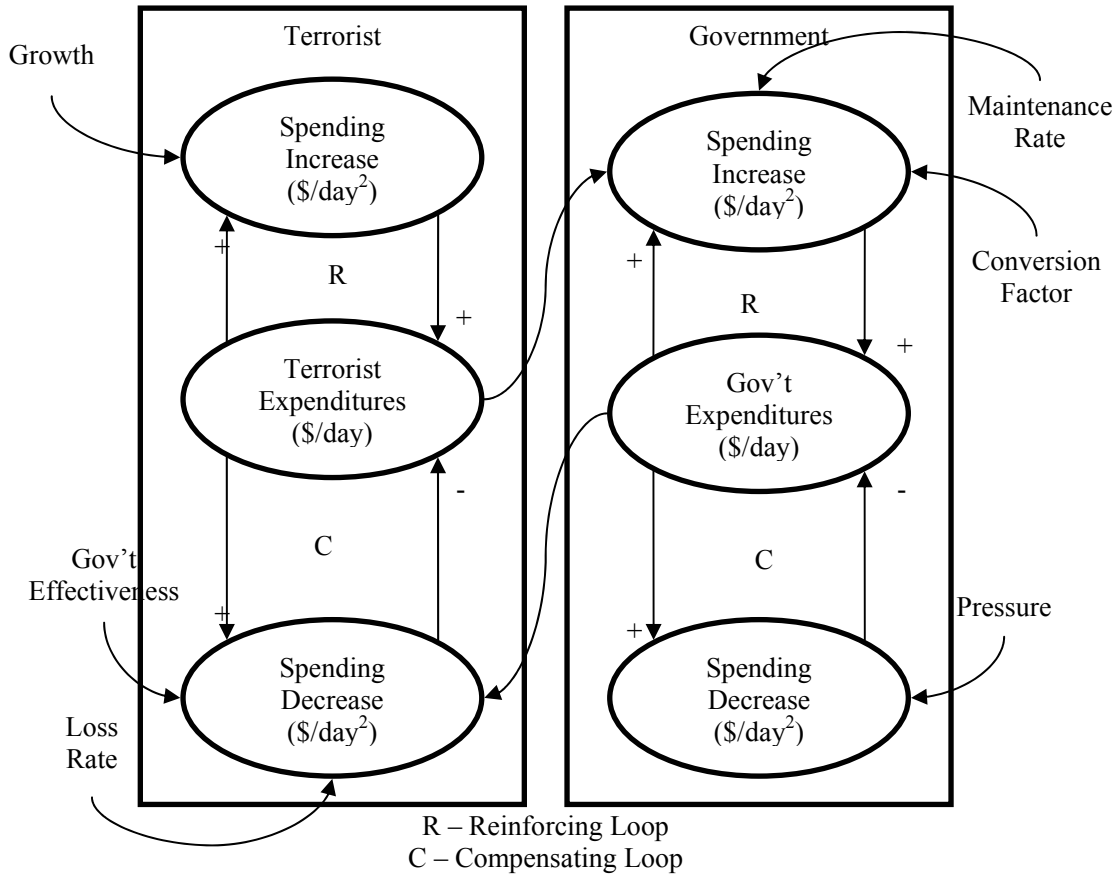


Figure 14. Model 2A Influence Diagram

On the government side of the model, the government increase in spending is based on the effectiveness of terrorist actions against the government, or the perceived threat posed by the terrorist group, and the required daily activities required to maintain

the organizational structure of the government counterterrorism activities. The terrorist effectiveness is a function of the terrorist daily expenditures and the conversion factor which determines the level of threat posed by the group based on the level of their activities. The maintenance activities required to maintain governmental organization is based on a level of government activity multiplied by a maintenance rate. Both parameters, conversion factor and maintenance rate, are assumed to be fixed for this model. Finally, the government decrease in spending is based on the political pressure to spend the money in another sector of government activity. This is function of the level of government activity and the corresponding pressure parameter, which is assumed to be constant for this model.

4.2.3 Step 3. Once the influence diagram was determined, it was converted with the Stella® simulation software into the flow diagram shown in Figure 15. Estimated values were assigned for the starting points of the endogenous stock variables and for the exogenous parameters because of the extremely high level of model aggregation and the fact that detailed numerical data on the subject was limited. The associated simulation behavior is shown in Figure 16, which clearly displays the oscillatory nature of the system. Although the initial spike was not an expected behavior of the model, the sinusoidal oscillation agrees with the reference mode.

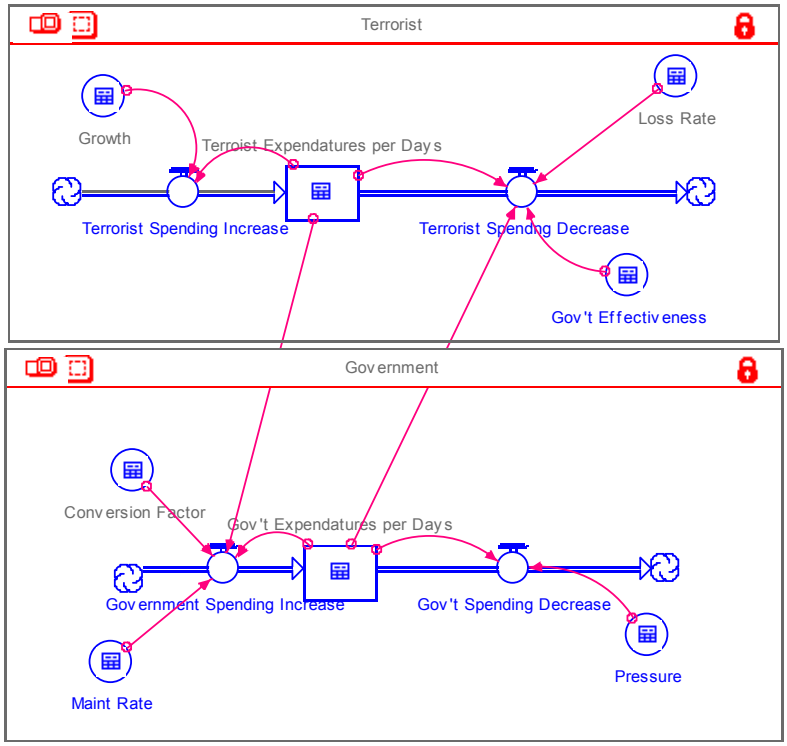


Figure 15. Model 2A Stella® Model

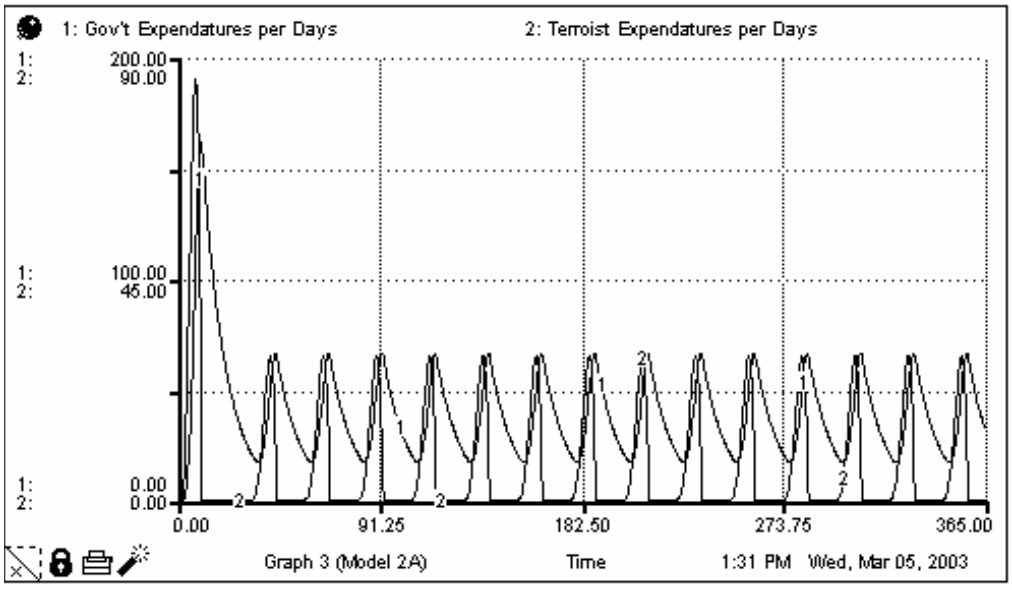


Figure 16. Model 2A Stella® Simulation Output

4.2.4 Step 4. From the information developed in steps 1 through 3, limited testing was performed on the initial model with some of the 12 tests identified in Chapter III. These tests helped determine how much additional detail was needed to more fully develop model series 2.

4.2.4.1 Boundary Adequacy Test. As stated in Chapter III, this test relies on the judgment of the researcher to determine the required level of detail to properly define the system boundary. For this test, the focus is on the influence diagram in Figure 14, which is a very basic representation of the system. However, the exogenous parameters are vague and do not provide any real help in studying the system. The endogenous variables are simple and directly related to the exogenous parameters with no internal feedback loops in the system. Therefore, it is clear that additional levels of detail are required to disaggregate the model to a more useful scope for this research. It might seem that this first iteration was too simple; however, this iterative process of building the model from its simplest form to a much more complex system builds confidence in the final model.

4.2.4.2 Structure Assessment Test. The focus of this test is on determining whether the model violates any real-world system conditions or laws. Addressing the three questions listed in Table 2 from Chapter III, the structure of the model is consistent with the system as understood at a very high level of aggregation. The model does not violate any natural laws, such as Newton's laws of physics or other commonly accepted laws of reality. However, as identified in Section 4.2.4.1, the level of aggregation is so high that model is not very useful in understanding the primary interactions between terrorist and government forces. Therefore, the model needs additional levels of detail to make it more applicable to the problem.

4.2.4.3 Dimensional Consistency. Dimensional consistency must be applied to all models. For model 2A, there are two stock equations and four flow equations; the actual equations from the Stella® program are shown in Figure 17. The units of measure for the stocks and flows are U.S. dollars per day and U.S. dollars per day^2, respectively. The dimensions for the exogenous parameters (conversion factor, maintenance rate, pressure, government effectiveness, growth, and loss rate) are a unitless percentage or efficiency on a per day basis. The resulting calculations on both sides of the equation result in the appropriate units (\$/day^2). The calculations for all model equations produced the proper results to satisfy this test. For the remainder of this document, dimensional consistency will be discussed only if it is violated by one of the models and cannot be explained and/or corrected.

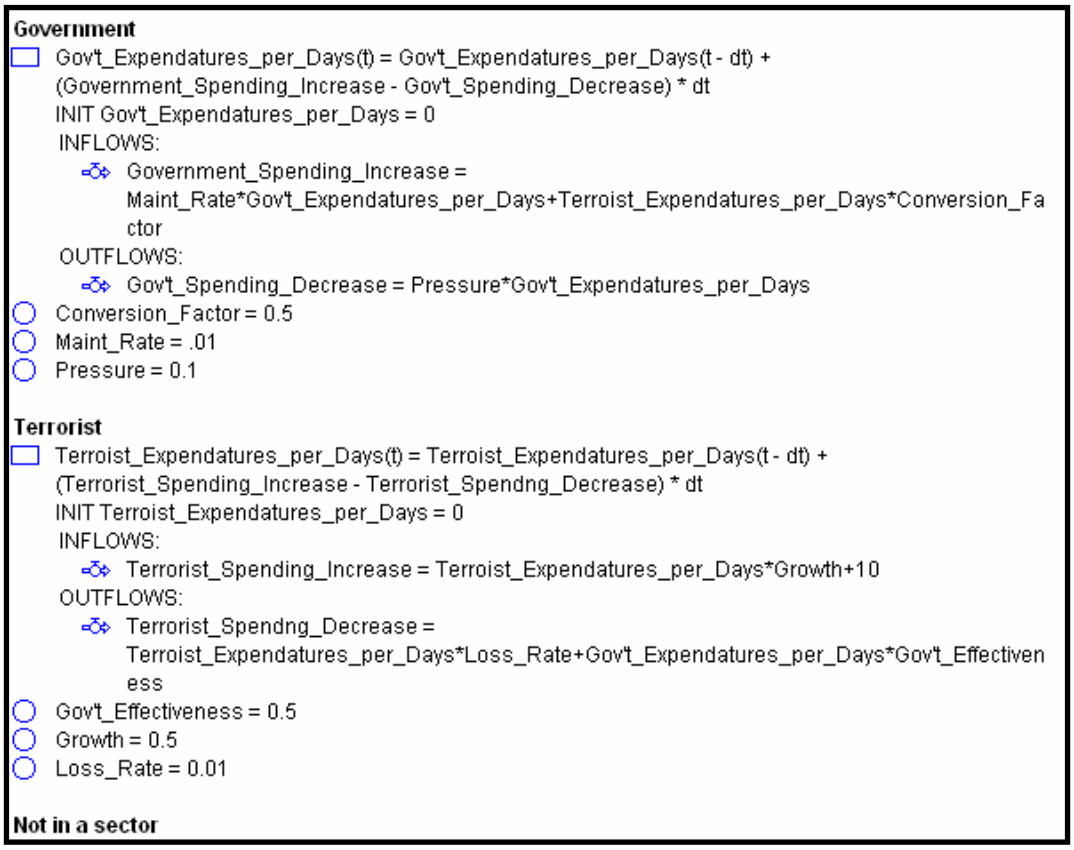


Figure 17. Equations for Model 2A

4.2.4.4 Parameter Assessment. Parameter assessment focuses on the proper delineation of the model parameters. Because the parameters for this research are extremely aggregated, educated estimates were used as model parameter values. As the system boundary is expanded and additional levels of detail are added, the model parameters will change and reflect new educated estimates. Section 4.6 covers the parameter assessment for the overall final model and includes a sensitivity analysis of selected model parameters.

4.2.4.5 Behavior Reproduction Test. Behavior reproduction validates whether the proposed model produces behavior similar to the real-world system being studied. Although Figure 16 does not identically match the hypothesized reference mode, it produces the initial oscillatory behavior exhibited by terrorist-government interactions and the lag in government actions. However, the frequency of the oscillations is debatable. The perceived reality is that the frequency would be smaller over a fixed period of time. This perceived reality is based on the fact that we are looking at terrorist daily activities, which for a full-time international terrorist would be close to steady state with fluctuations in activity based on the level of government activity. This is possible since many terrorist organizations, such as Al Qaeda, attempt to cover up their daily activities in order to hinder the efforts of government forces. As additional levels of model detail are added, the oscillations should smooth out to more closely resemble the overall expectations. These additional levels of detail include better definitions of the endogenous variables and exogenous parameters.

4.2.4.6 Surprise Behavior Test. The surprise behavior test for the model is reflected in Figure 16, which demonstrates the terrorist behavior spiking before the government behavior. Figure 16 also shows that the first spike was the largest. These behaviors have been observed in real-world events. Recall from Chapter II that the start of modern terrorism was the 1968 Palestinian hijacking of an Israeli airliner. However, structured government counterterrorism response did not occur until after the terrorist attacks at the 1972 Munich Olympics (Hoffman, 1998:72-73). In other words, terrorists are typically instigators and benefit from the element of surprise, while the government is typically in a reactionary mode. This can also explain the disparity in the first spike as

compared to the following oscillations. If the government operates a consistent counterterrorism policy, it is assumed that the initial terrorist daily activity will be greatest before the government's attention has been focused on that particular terrorist group.

However, this assumption is flawed because it does not take into account many other factors that account for terrorist daily activity. First of all, it assumes that terrorist activity is only affected by the actions of one government, which is not always the case. Second, it does not account for non-governmental constraints placed on terrorist groups, such as the needs or requirements of the terrorist's sponsors. These flaws will not be addressed in this study. However, other flaws in the assumption will be addressed by the iterative development of the overall model.

4.2.5 Step 5. Step 5, described in Chapter III as policy design and evaluation, was not addressed with model 2A since the decision was made to modify the model before it reached this step. As previously mentioned, step 5 was not a major portion of this study. Instead, it will be left to later research, since the motivation of this study is to define the existing system. However, the sensitivity discussed in Section 4.6 will demonstrate how Step 5 can be applied to policy development once better data has been acquired for the model.

4.2.6 Additional Iterations of Model. The final two models in model series 2 are called model 2B and model 2C. Model 2 B is covered in Section 4.2.6.1, while model 2C is covered in Section 4.2.6.2.

4.2.6.1 Model 2B. Model 2B builds on model 2A by examining an additional level of detail for the effect of government activities on terrorist activities. The major

assumption in model 2B was that there are three types of government activity: offensive action, defensive action, and intelligence action. The level of government spending for each of these actions is based on three new exogenous model parameters: government counterterrorism operations (GCTO) coefficient, government defensive (GD) coefficient, and government intelligence (GI) coefficient.

This breakout of government action caused a major change in the model by shifting the government effectiveness from an exogenous parameter to an endogenous variable and creating a mirror image variable called terrorist effectiveness. The new government effectiveness variable is based on government counterterrorism operations and government intelligence, where government intelligence is expressed as an efficiency of government action based on how much the government spends to learn about terrorist actions. The terrorist effectiveness variable is used to calculate how much terrorist activity is thwarted by government defensive actions.

This model introduces a new type of Stella® variable, the graphic variable. In a graphic variable, the Y-axis represents the value of the variable and the X-axis is the criteria by which the variable is measured. Model 2B introduces two graphical variables: government defense and government intelligence. Both variables are considered to be a percentage, are bound by values between 0 and 1, and have a near S-shaped behavior as shown in Figure 18.

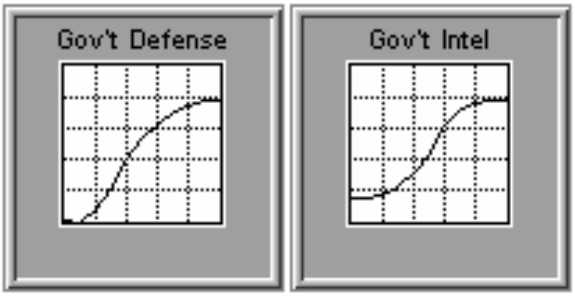


Figure 18. Model 2B Graphical Variables

The government defense variable represents the percentage of daily terrorist activity that is interrupted by government defensive actions based on how much government activity is spent on this variable. The lower bound of this variable is zero; if the government spends nothing on defense, it cannot interrupt terrorist activities. The upper bound is set at 0.8 since the government cannot intercept all terrorist activity, regardless of how much time or money they spend on defense.

Similarly, the government intelligence variable measures how effective government activity is based on how much the government knows about terrorist actions, which is dependent on how much the government spends on terrorism. The idea behind this variable is that if the government knows 50% of the terrorist daily activities, then only 50% of the government activities, offensive or defensive, will be effective. The rest of the government activity is considered to be ineffective. The range of the government intelligence variable is set from 0.165 to 0.8; if the government spends nothing on intelligence, it will have some minimal knowledge of terrorist activity based on non-governmental sources of intelligence, news services, etc. However, regardless of how

much the government spends on intelligence, it is relatively impossible for the government to have full knowledge of terrorist activities.

Model 2B consists of two sub-models to isolate the effects of offensive and defensive actions, as shown in Figure 19. Both sub-models include an associated government intelligence term and were developed to examine the individual effects of the respective system dynamics structures on the simulation output. The additional causal loop added by government defensive actions resulted in the reduction of the oscillation amplitude and the separation between oscillations as shown in Figure 20, which is expected due to the nature of the defensive actions. The refinement of an existing causal loop added by government offensive actions resulted in a significant reduction in the frequency of oscillation but a significant increase in the amplitude of the oscillation when compared to the output of the government defensive actions. This makes sense since the government defensive actions are intercepting actual terrorists daily actions.

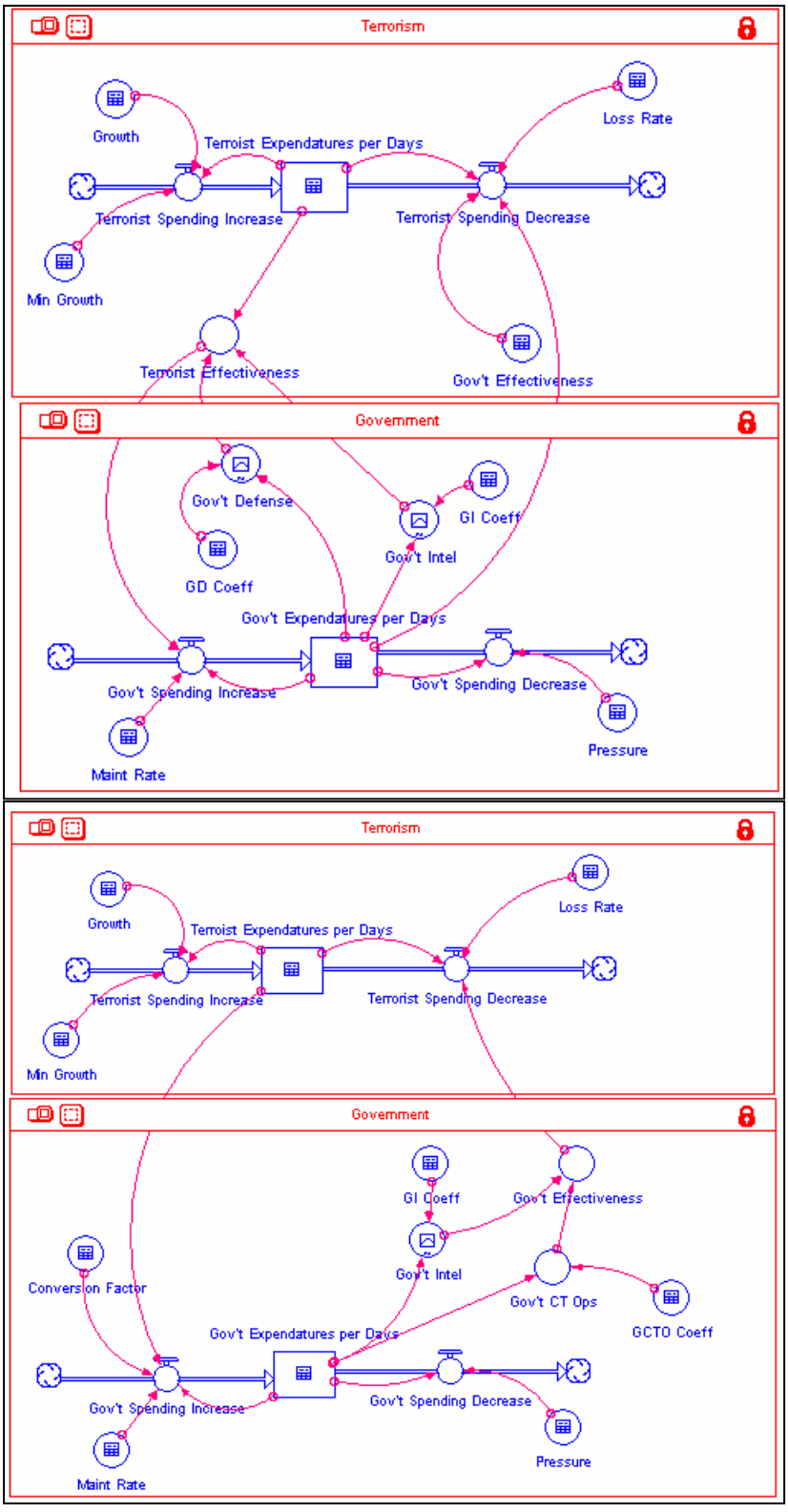


Figure 19. Model 2B Sub-models

Top – Model 2B1; Bottom – Model 2B2

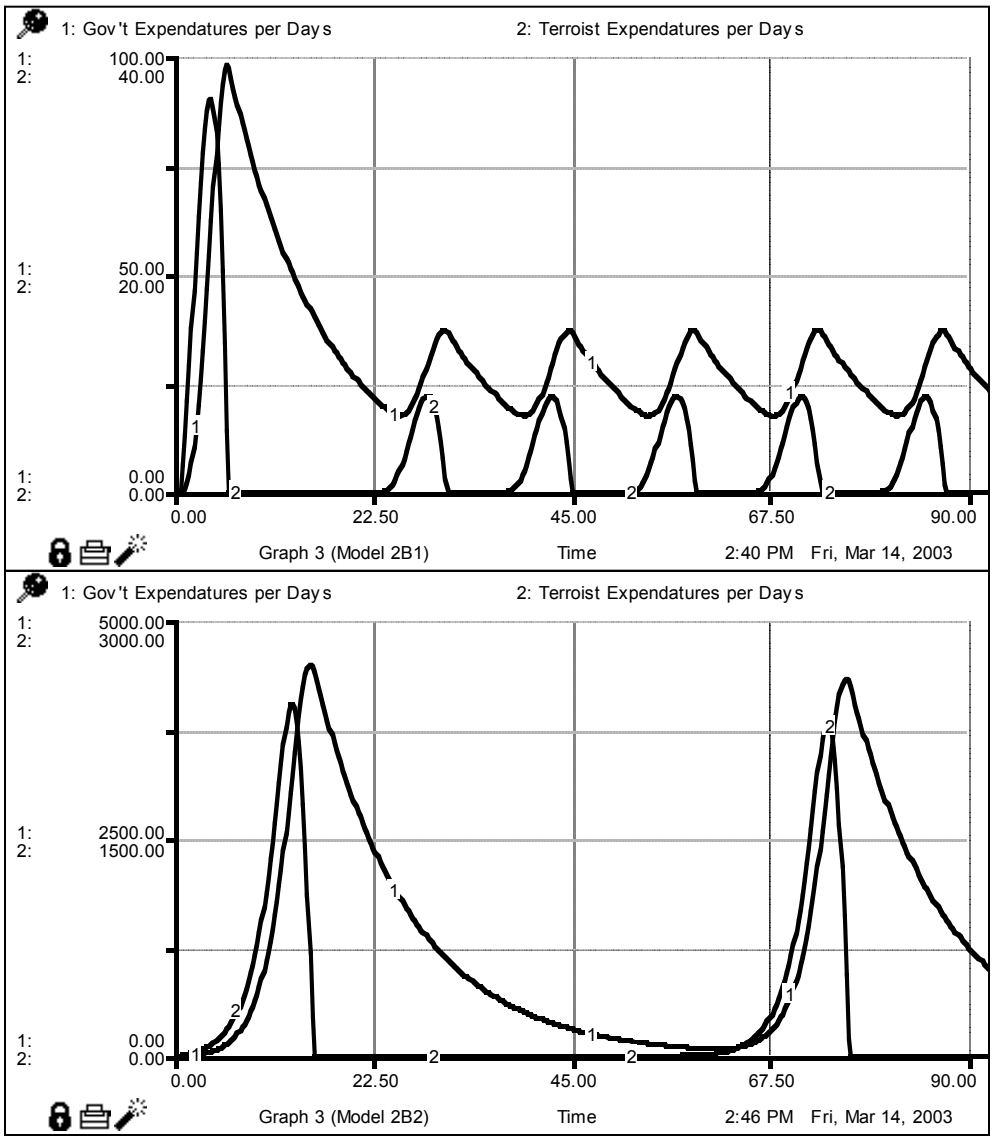


Figure 20. Model 2B Sub-models Outputs

Top – Model 2B1; Bottom – Model 2B2

4.2.6.2 Model 2C. Model 2C added the same level of detail to the terrorist daily activity side that model 2B added to the government side and introduced two new variables and three new parameters. The two variables were terrorist operations and terrorist intelligence. Using the same justifications used in model 2B, the terrorist

activities were broken out into terrorist operations and intelligence actions. A terrorist defensive action was not created, because there was no apparent need for it; however, this will be corrected in later model series. The terrorist intelligence variable is almost identical to the government intelligence variable. It also utilized an S-shaped graphical variable, but the range was changed to a minimum value of 0.25 and a maximum value of 0.9. The minimum and maximum values are higher for the terrorist groups as compared to the government since it is much harder for governments to hide their counterterrorism activities. The variable terrorist operations encompassed all terrorist daily activities except terrorist intelligence.

The three parameters added in model 2C are the two coefficients determining terrorist's expenditures on terrorist operations and terrorist intelligence and a quantification of the old conversion factor which was changed to the terrorist amplification factor, which accounts for the return on investment terrorists get for their operational activity. If a terrorist spends $1/day on operational activity, the actual value of the activity observed by the government is $100/day. As seen in Chapter II, this amplifying factor has been increasing in recent years with the average damage and death per attack steadily increasing (Medd and Goldstien, 1997; Quillen, 2002a). Model 2C resulted in the Stella® model and simulation output shown in Figures 21 and 22, respectively.

The simulation output shown in Figure 22 reflects the initial spike explained with model 2A. However, the following terrorist and government actions reach steady-state oscillations with a distinct difference in the average amount of action from each respective entity. As identified in Chapter II, this behavior was expected since the

terrorists have the advantage of surprise and target selection. These advantages force the government to work harder on defensive measures than the terrorists have to work on offensive measures. Based on these evaluations of the model simulations, the decision was made that model 2C displayed an acceptable level of aggregation for terrorist daily activity for this point in the overall modeling process.

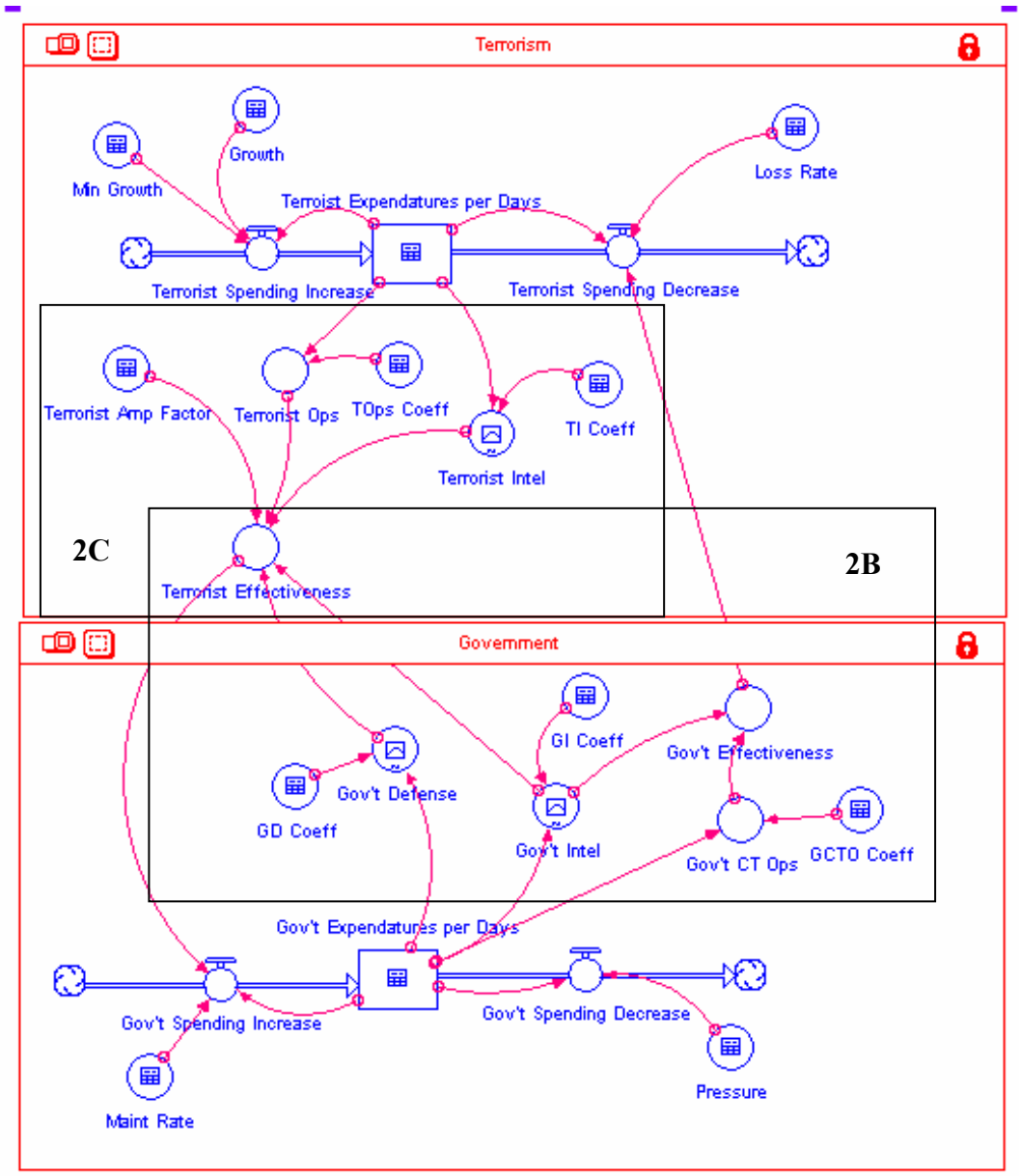


Figure 21. Model 2C Stella® Model

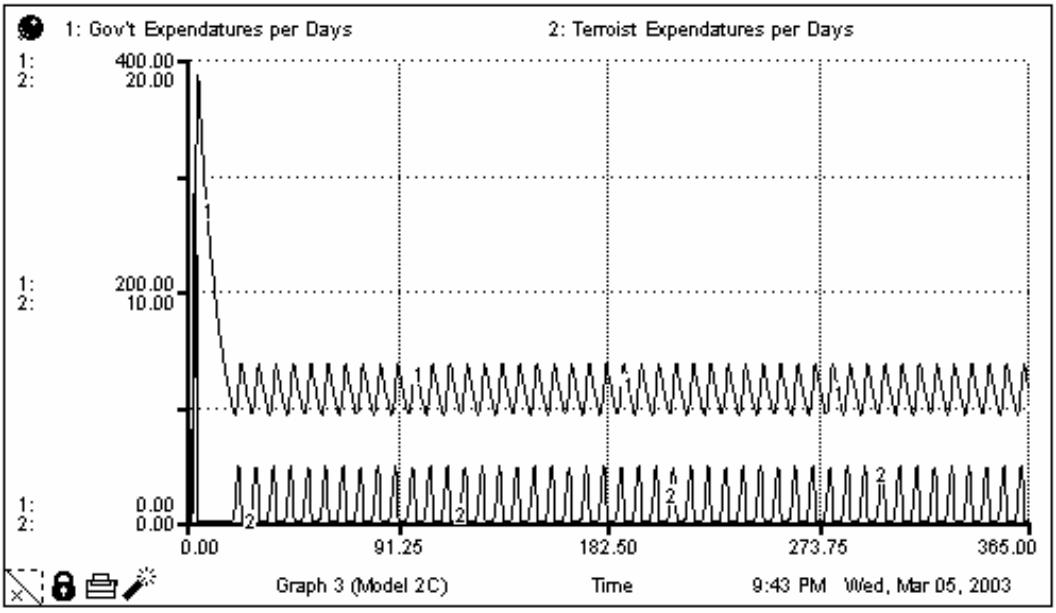


Figure 22. Model 2C Graphical Output

4.3 Model Series 3

Model series 3 was the first attempt at modeling terrorist significant events, i.e., specific terrorist activities associated with conducting significant terrorist attacks. For this study, significant terrorist attacks are considered to be large-scale attacks similar to Quillen's (2002a) mass casualty attacks but without the defined categorization limit (e.g., at least 25 fatalities). This model series hypothesized that terrorist significant events were based on an overshoot and collapse structure in which the terrorist had to acquire a resource base before they could execute their attacks. After five iterations of this model series, the determination was made that the goal-seeking growth of model series 4 would be a more accurate representation of the system behavior. However, many of the lessons learned in model series 3 were carried over into the development of model series 4. Most

notable of these was the realization that certain terrorist daily activities support terrorist significant event activities. While this is intuitive in real-world events, it is more complicated in the modeling process and required further disaggregation of model 2C.

4.4 Model Series 4

The goal-seeking structure used in model series 4 was designed to match the reference mode shown in Figure 23. The simulation output for the associated goal-seeking structure reaches a desired steady state solution as shown in Figure 24. The theory for model series 4 was that the terrorist organization, as with any modern organization, had some operational goal they were striving to achieve. The goal-seeking structure utilizes a parameter which establishes the goal, a stock, a flow, and a converter variable that measures the difference between the goal and the stock.

Two assumptions were used to modify this basic goal-seeking structure in the development of model series 4. First, it was assumed that the terrorist would initiate a significant event attack as soon as they had stockpiled the required resources. This would cause the significant terrorist activities to drop to zero and restart the cycle, thereby creating an oscillatory behavior where the basic system dynamics oscillatory structure does not exist. Second, it was assumed that the more resources the terrorist had stockpiled, the greater their ability to accumulate additional resources. This feedback loop to the stock created an S-shaped growth of the resource stock. For additional reference, the entire final model for this series, model 4K1, is included in Appendix B.

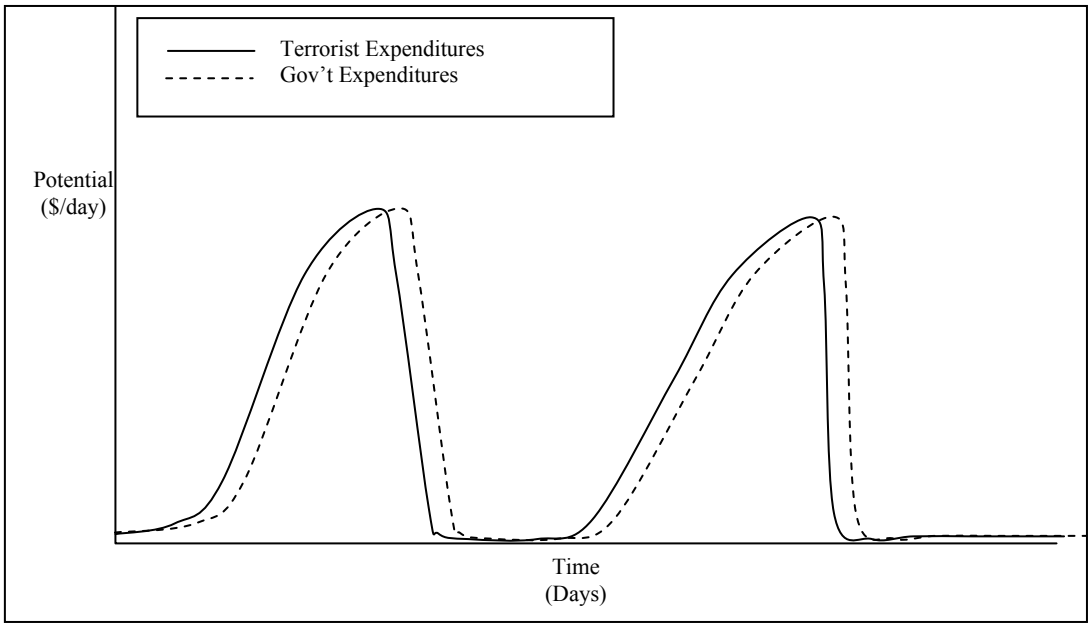


Figure 23. Terrorist Significant Event Reference Mode

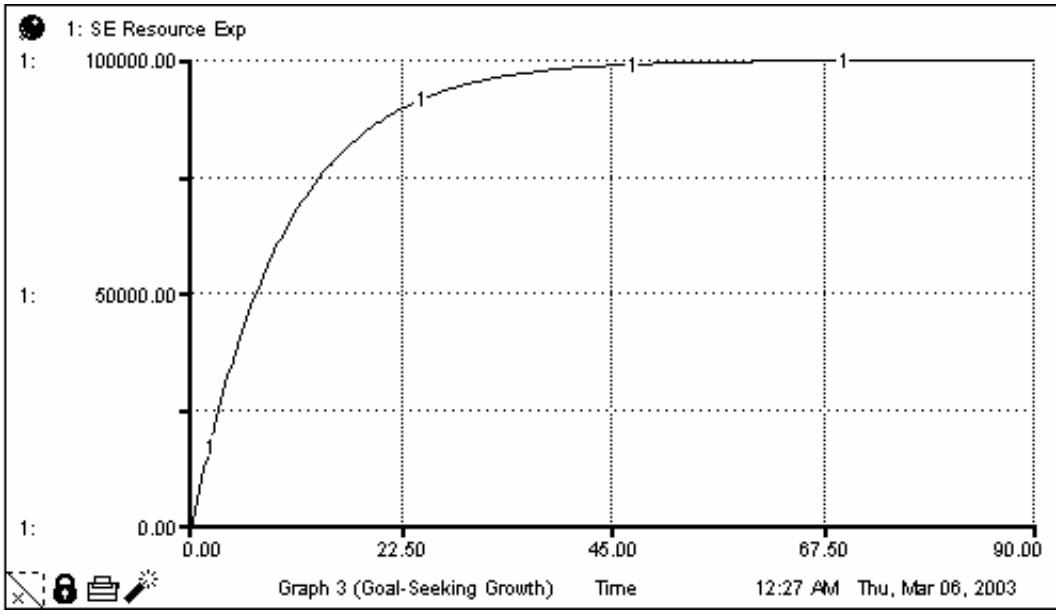


Figure 24. Model 4A1 Goal-Seeking Growth

The first three iterations of model series 4 (4A, 4B, and 4C) focused solely on producing the desired goal-seeking behavior for the terrorist significant event portion of the reference mode. After determining an adequate goal-seeking structure, eight more iterations (4D-4K1) were conducted to add government interactions and additional levels of detail, thereby creating a combined model.

4.4.1 Goal-Seeking Structure. As identified earlier, it was hypothesized that the terrorist had a set number of activities that had to be accomplished for the attack to be executed and considered successful. This premise served as the foundation for the basic goal-seeking structure, which is shown as model 4A2A in Figure 25. This structure consisted of four parameters and three variables. The four parameters were momentum, initial inflow rate, goal-discrepancy (GD) flow rate, and the goal. The three variables were significant event (SE) resource expenditures, resource acquisition, and percent of goal.

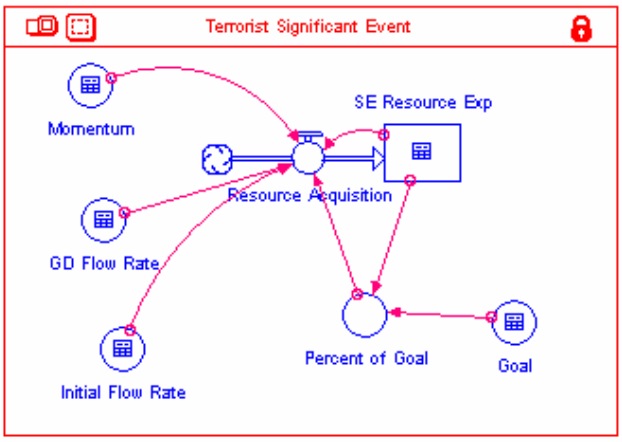


Figure 25. Stella® Model 4A2A

The stock, significant event resource expenditures, is influenced only by the flow, resource acquisition. The flow is a function of the percent of goal, the goal-discrepancy flow rate, the stock, the momentum, and the initial flow rate. The flow is determined by the sum of the flow factors times one minus the percent of goal. The goal-discrepancy flow rate is the flow factor initially; at this point, it is assumed to be a constant parameter. However, later in the overall model development, it will a variable of daily terrorist activity. The momentum rate is based on the second assumption above that the more resources that are stockpiled the greater the terrorist ability to acquire additional resources. The one minus the percent of goal term slows down the flow and turns it off as the resource expenditures reach the required goal. The percent of goal variable simply divided the level of the stock by the goal to measure the percent of goal that had been attained by the terrorist. The overall result is the goal-seeking behavior shown in Figure 26.

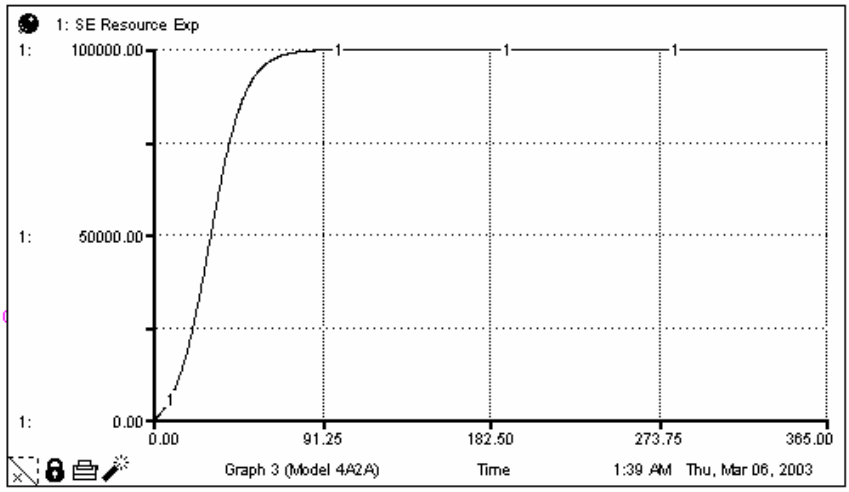


Figure 26. Model 4A2A Stella® Output

Model 4B, shown in Figure 27, built on model 4A2A by adding a mechanistic outflow to the system to indicate that the terrorist would initiate an attack when they got within an acceptable percentage of their goal. The outflow is an "If-Then-Else" statement that monitors the percent of goal variable to determine when it reaches the acceptable level identified in the minimum percent required parameter. When the percent of goal is equal to or exceeds the minimum percent required the outflow equals the value of the stock. However, if the DT as defined in Chapter III is less than 1, the outflow will not be able to completely empty the stock. Since this outflow empties the stock when the acceptable level of the goal is reached, this immediately restarts the process of acquiring additional significant event resources and produces the "false" oscillation shown in Figure 28. This figure illustrates the oscillation created by the system's constant desire to attain the desired goal but always being reset to zero just before it can reach that goal.

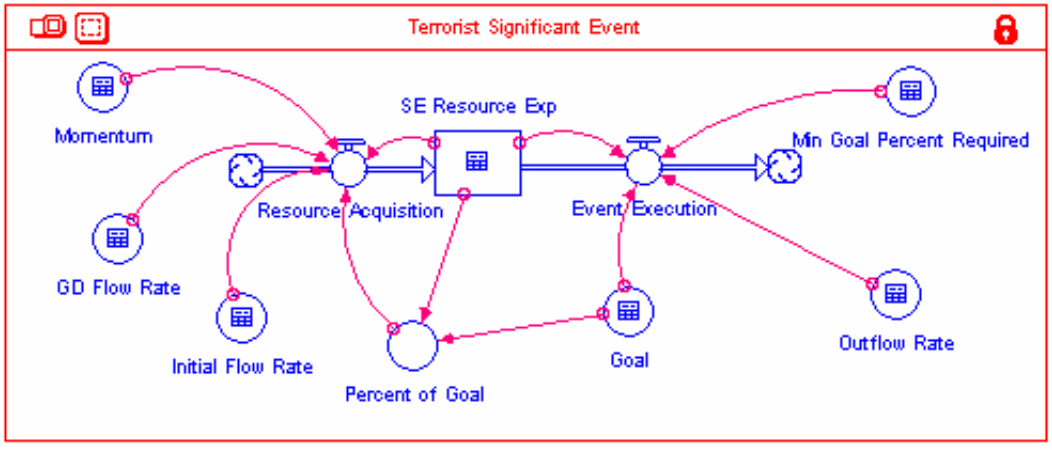


Figure 27. Stella® Model 4B1

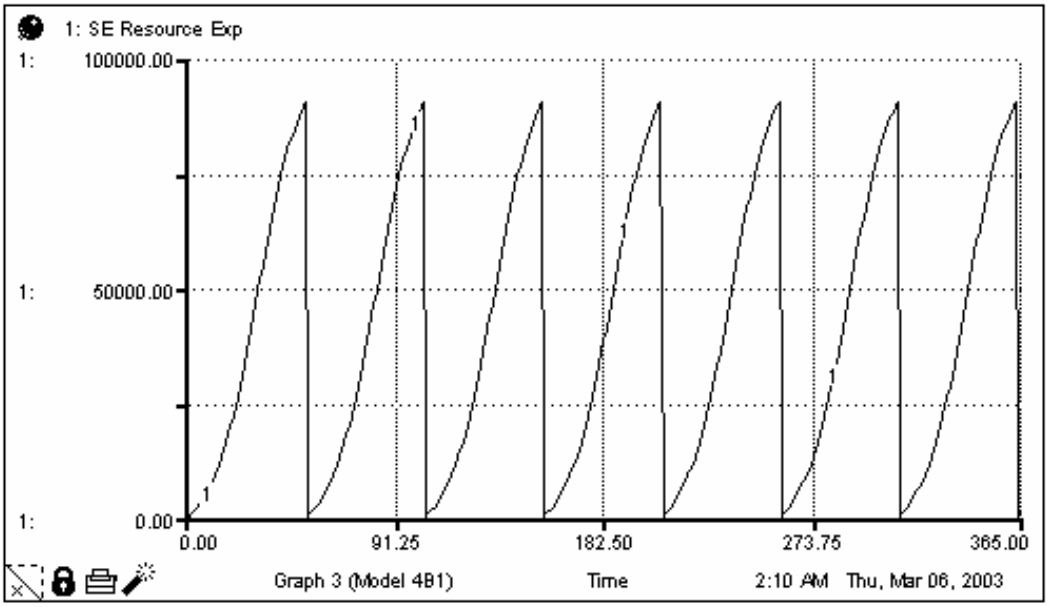


Figure 28. Stella® Model 4A2A Output

In system dynamic terms, this oscillation is considered to be false because it is not being driven by an oscillation system dynamics structure similar to the structure of model 2A in Figure 14. Intsead, this oscillation is being driven by the mechanistic outflow. Although this models real-world conditions in an acceptable manner, if the researcher does not account for the behavioral effects of this mechanistic outflow in the evaluation of the final model, the researcher can mistakenly credit model oscillation to a dominant causal loop structure instead of the mechanistic outflow. By identifying the oscillation as false, the researcher can avoid misinterpretations as to the causes of the oscillatory behavior.

Overall, this mechanistic outflow was a source of trouble throughout the rest of the modeling process because of the type of mechanistic structure and the DT. These limitations were later identified and corrected in model series 5. The structure problem is

caused by the fact that the same goal driving the inflow also drives the outflow. In later models when government actions start to erode terrorist resources, it becomes impossible to simulate a significant event execution, even though common sense says that the terrorists will try to attack early, postpone the attack, or redirect the attack in order to prevent the government from taking their significant event capability away. These issues will be addressed in detail as they arise.

Model 4C1, shown in Figure 29, disaggregated model 4B1 to a level acceptable to the overall model and to show how the two terrorist sectors of the model interact before the government interaction with the terrorist significant event was included. Because one large parameter was exchanged for four smaller parameters, this iteration had no significant impact on the development of model series 4. However, this change is expected to have a significant impact in the overall model development because it ties the two terrorist sectors of the larger model together. These activity inflow terms are exogenous model parameters in the model series 4 simulations but are actually part of the endogenous variable terrorist operations from model series 2. This makes them endogenous variables of the overall model. This interaction between the two sectors of the model is corrected in model series 5 when the two model series (2 and 4) are merged.

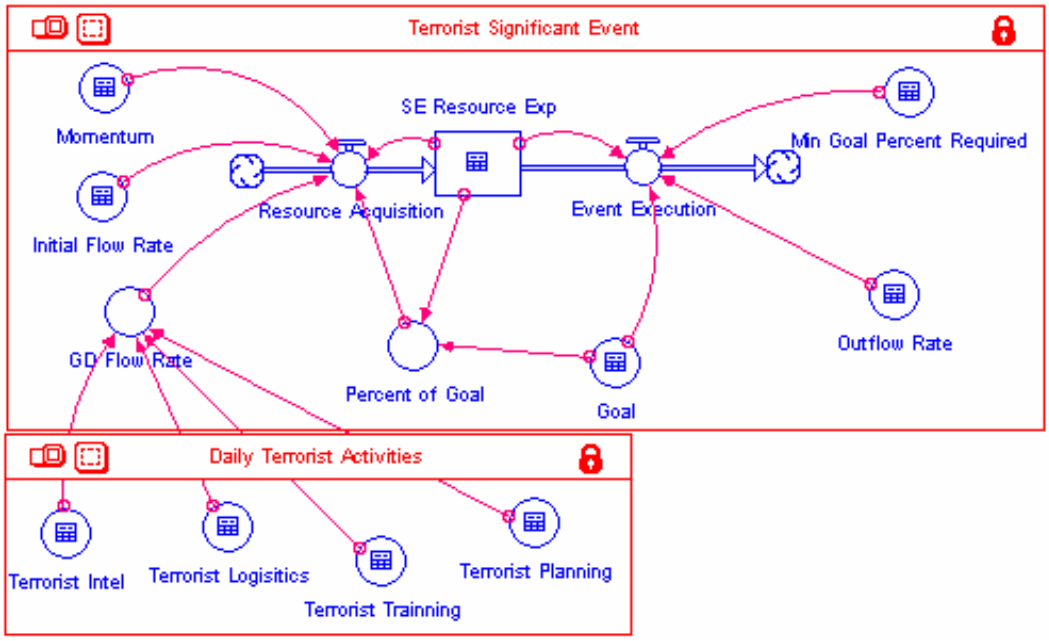


Figure 29. Model 4C1 Basic Terrorist Significant Event Structure

4.4.2 Goal-Seeking combined with Government Interactions. Models 4D through 4K add government interactions to the terrorist significant event model structure and iteratively develop the interactions between the two model sectors. These models provide a greater level of detail regarding the interactions between terrorist daily activity, terrorist significant event, and the government. While the government side of the model is very similar to that for model series 2, the following concepts were added: terrorist impact, terrorist visibility, and government political will. The process for developing each of the models is identical to the process previously described. Therefore, only a brief summary of each model's contribution to the overall development of model series 4 will be provided with a detailed look at variable and parameter interactions and the

overall output of model 4K1. The model structure discussion regarding models 4D through 4K are referenced in Figure 30.

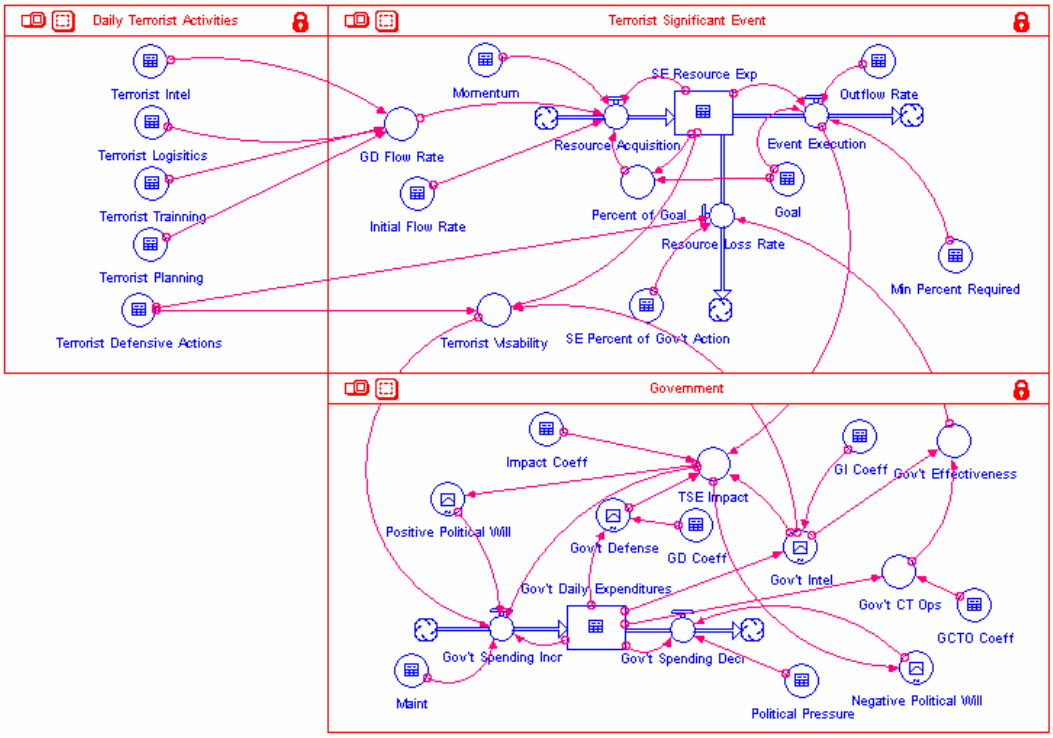


Figure 30. Stella® Model 4K1

Model 4D2 added the basic interactions from the government sector model structure, which were developed in model 2A and described in Section 4.2, to the terrorist significant event sector of the model. To accommodate these new system interactions, a second outflow was added to the significant event resource expenditures stock to simulate resources lost because of government action. This kept the resources used in significant event execution, the mechanistic outflow, as a separate model entity. Model 4D2 also

added the new concept of significant event percent of government action as a new model parameter. This new parameter recognizes the reality that the total amount of government action has to be split between the terrorist significant event and terrorist daily activity sectors of the model. The most significant impact from model 4D2 was the model output. The structure created by the addition of government interactions created a dampened oscillation which approached steady state as shown in Figure 31. This provides hope that when the model is fully developed and properly parameterized a government policy can be created to control the overall system behavior. Figure 31 has been limited to the first 120 days of the 365-day model run since these days include the vast majority of the oscillations.

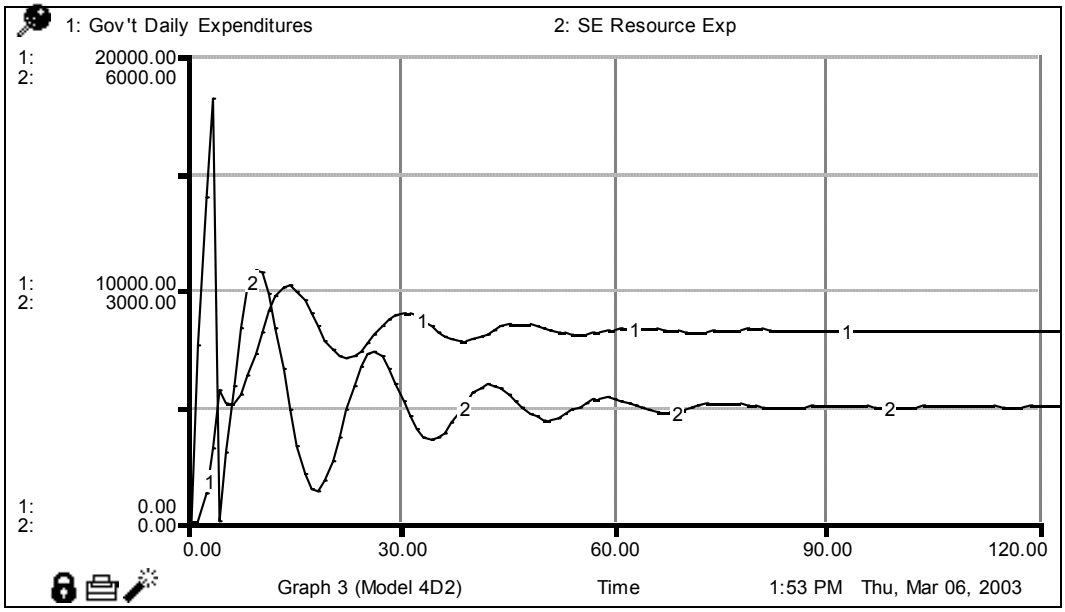


Figure 31. Stella ® Model 4D2 Output

Model 4E1 and model 4F1 refined model 4D2 by breaking out government actions in the same way that model 2B broke out these actions. In order to facilitate the merger of model series 2, the parameters and graphical variables for models 4E1 and 4F1 were set to match the same parameters and variables used in model 2C. Model 4F1 demonstrated that the government actions to the terrorist significant event resource stock were actually the result of the government's visibility of these terrorist actions and not necessarily the efficiency of these actions. These realizations led to the development of model 4G2, which added a variable for terrorist visibility and a parameter for terrorist defensive actions. The justification for these additions is from the Chapter II discussion that terrorist groups, such as Al Qaeda, actively try to hide their preparation activities from the government to ensure operational security.

Model 4H1 expands on model 4G2 by adding the actual terrorist attack to the model. The attack variable is identified as terrorist significant event (TSE) impact, which is based on the amount of terrorist significant event resources utilized in the event execution. It also includes a new parameter for impact coefficient to determine the expected rate of return for terrorists from a terrorist significant event attack. Terrorists enjoy a significant rate of return for the amount of damage they inflict compared to the damage that is inflicted on the government or society.

Model 4I1 reintroduces the government defensive actions that were initially added during model 4F1 but removed for model 4G2. The terms used for government defense are identical to those developed in model 2B. In model 4I1, the government defense is used as mitigation term in figuring the variable of TSE impact. Similar to model 2B, the

government defense graphic variable is expressed as an efficiency of the terrorist impact by indicating the percentage of terrorist actions foiled by government defensive actions.

Models 4J1 and 4K1 expand upon model 4I1 by introducing the idea of political will to the model series 4 development. Initially, political will was defined by two variables, one for positive political will and one for negative political will. Positive political will uses TSE impact and a step function to calculate the political will of governmental leaders to increase spending for terrorism based on the severity of a significant terrorist attack. The negative political will calculates the erosion of political will based on the lack of significant terrorist attacks. The idea of political will and how to model it was refined later in model series 5.

This iterative process for models series 4 culminated in the development of model 4K1, which is shown in Figure 30; its associated simulation output is shown in Figure 32. Overall, each iteration improved the model output; however, as each level of detail was added, it became more difficult to simulate the significant event execution. Despite this difficulty, the overall level of model detail was considered appropriate for this point in the modeling process.

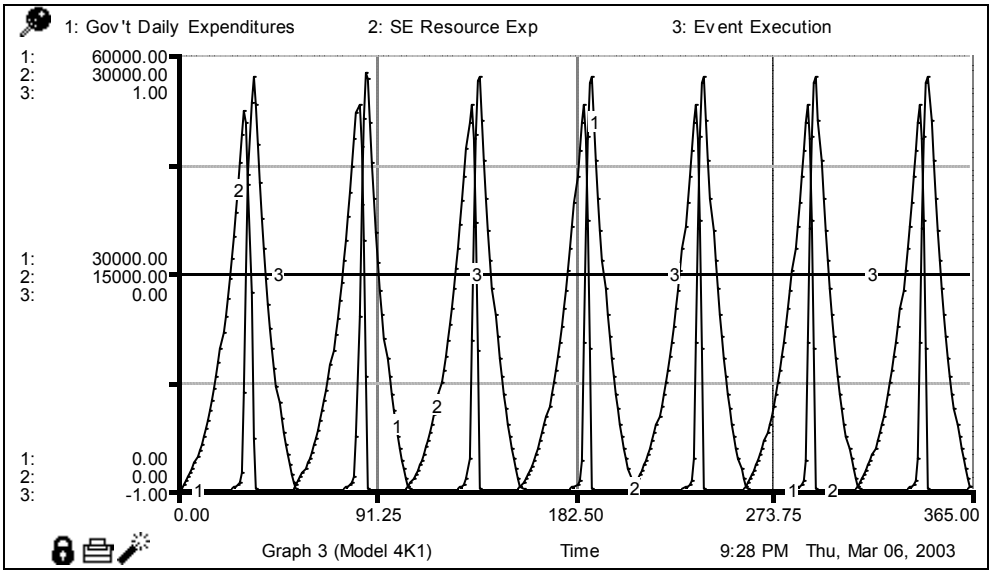


Figure 32. Stella® Model 4K1 Output

To summarize, model 4K1 has 7 endogenous variables and 6 exogenous parameters in the terrorist significant event sector of the model, as well as 5 exogenous parameters from the terrorist daily activity. A key difference between model series 2 and model series 4 is that the terrorist significant event (TSE) flows are in $/day and the stock is in U.S. dollars. The stock is significant event (SE) resource expenditure supported by the resource acquisition inflow, the event execution outflow, and the resource loss rate outflow. The stock has two outflows to distinguish the difference between the loss of resource due to a significant event execution and resource loss rate due to government actions.

The resource acquisition inflow is driven by the goal-discrepancy (GD) flow rate, percent of goal, and the SE resource expenditure stock variables, as well as the parameters for momentum and initial flow rate. The GD flow rate variable is the

summation of the terrorist daily activities that support the TSE preparations as represented by five parameters: terrorist intelligence, terrorist logistics, terrorist training, terrorist planning, and terrorist defensive actions. The percent of goal variable monitors the difference between the set goal for the SE resource stock and the actual level of the stock. As the stock approaches the set goal, the acquisition of resources is slowed.

The two TSE outflows interact with the government sector of the model. The resource loss rate is affected by the amount of direct government actions applied against the TSE stock and is calculated from the product of the government effectiveness variable and the SE percent of government action parameter. The SE execution outflow was described in the earlier discussion of model series 4. The SE execution drives the TSE impact variable, which calculates the damage caused by an attack based on the government defensive measures and on the impact coefficient parameter. The TSE impact variable is a player in the total terrorist impact and the driver for the government variable of political will.

The government sector has 10 variables and 6 parameters. The government stock is government daily spending with an inflow of government spending increase and an outflow of government spending decrease. The government spending increase is driven by the variables TSE impact, terrorist visibility, positive political will, and the government daily expenditures; it is also driven by the maintenance parameter. The spending decrease structure is driven by the negative political will and government daily spending variables and the political pressure parameter.

Government daily spending drives threes types of government actions: defense, counterterrorism operations, and intelligence. The government defensive action and

government intelligence are graphical variables which were discussed in Section 4.2.3. The government counterterrorism operations are offensive actions taken against the terrorists. The combination of these parameters with government intelligence forms the government effectiveness variable which determines the effectiveness of government offensive actions.

4.5 Model Series 5

Model series 5 combines the terrorist daily activities model (model series 2) and the terrorist significant event model (model series 4). Six iterations were used to develop model series 5 into the final model. The primary reason for these iterations was correct errors previously identified. The primary errors that were addressed included an inappropriate iteration time difference (DT), the consolidation of the separate positive and negative political will variables, the redefinition of the mechanistic event execution outflow variable, the redefinition of the government decrease in spending outflow variable, and other minor model changes required by the merger of the two model series.

4.5.1 Model 5A. Model 5A combined the final models from model series 2 and model series 4. Model 5A1, shown in 33, changed the DT from 1 to 0.1, which significantly smoothed out the appearance of the simulation output as shown in Figure 34. When compared with Figure 35, the pattern of behavior did not significantly change from model 5A. The major change in model 5A1 was the introduction of the terrorist daily activity (TDA) sector. As previously discussed, the development of the TSE sector in model series 4 identified the need to represent the original TDA terrorist operations variables as five separate variables with five corresponding parameters to identify the

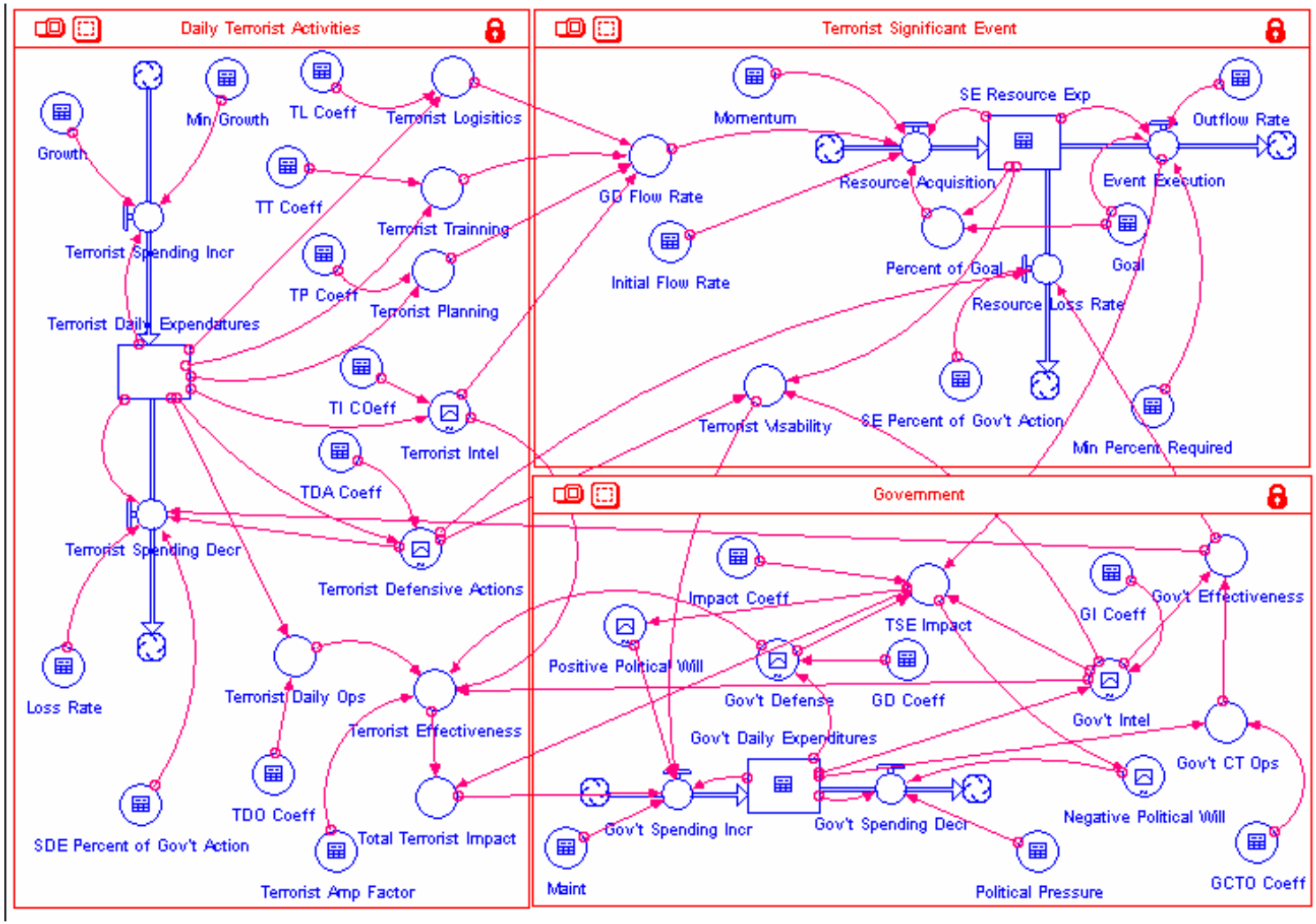


Figure 33. Stella ® Model 5A1

percent of terrorist spending earmarked for each variable. This gave the TDA sector of the model 11 endogenous model variables and 11 exogenous model parameters. The primary variables for the TDA sector are the terrorist daily expenditures stock and its two associated flows, terrorist spending increase and terrorist spending decrease. The level of the stock drives six of the other variables in this section which represent how the terrorists spend their money. Those variables are terrorist logistics, terrorist training, terrorist planning, terrorist intelligence, terrorist defensive actions, and terrorist daily operations. Each of these variables has an associated model parameter, identified as a coefficient, which identifies what percent of the total terrorist daily spending is spent on the activity. The terrorist intelligence and terrorist defensive actions have been defined as graphical variables and will be discussed in Section 4.6.

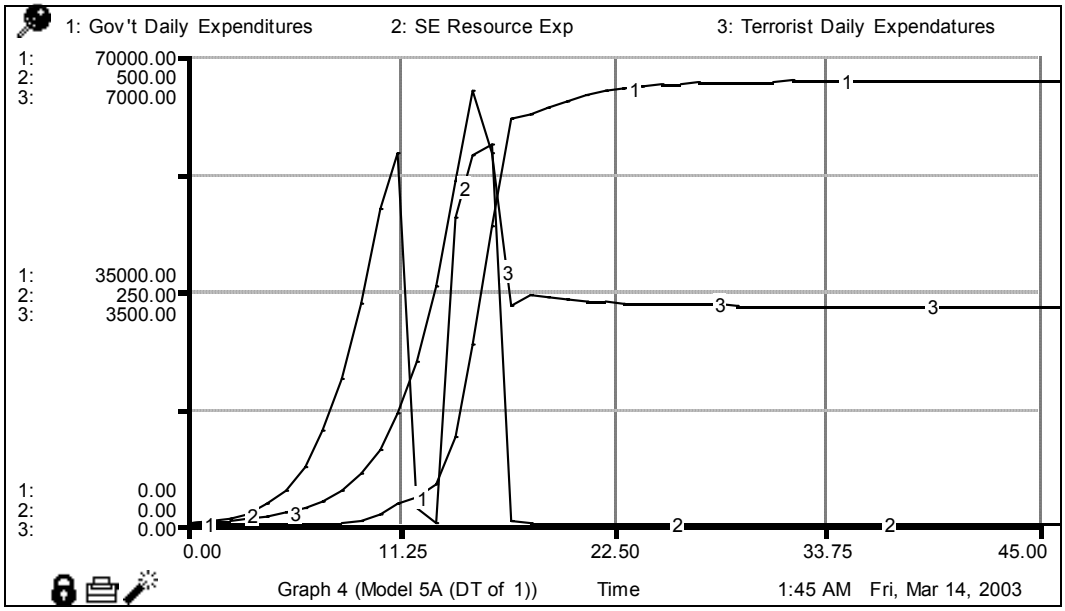


Figure 34. Model 5A Output Using a DT of 1

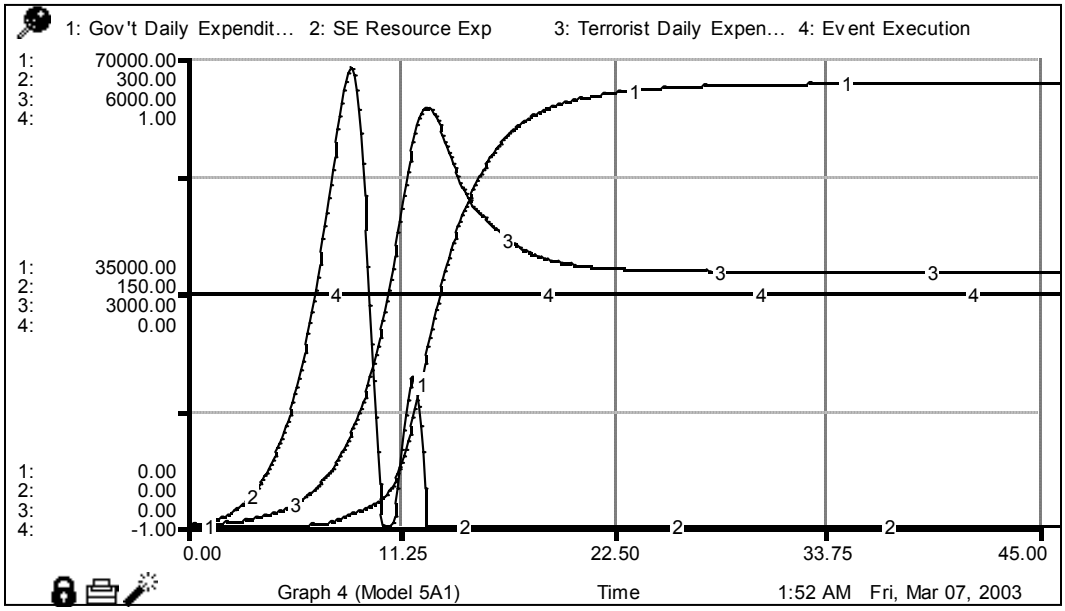


Figure 35. Model 5A1 Output Using a DT of 0.1

Terrorist logistics, training, and planning are all activities that drive the terrorist significant event activities. Since these activities have the same amplification factor, there is no inherent benefit to have three separate variables. However when future research better defines these amplification factors with real world data, there will be an added benefit to having these three activities disaggregated in the model. The terrorist daily operations variable covers all other terrorist activities that impact the government and are not related to the TSE sector of the model. These can include small scale attacks, normal organizational maintenance, etc. While these actions may or may not directly target the government, the government's visibility of these actions will cause a government response. These daily operations are combined with terrorist intelligence and a general terrorist amplification factor to create the terrorist effectiveness variable,

which is combined with the TSE impact variable to create the total terrorist impact. This total terrorist impact is a driver in how the government increases spending.

The behavior for model 5A1 was shown in Figure 35. As seen in the graph, all three stocks reach a steady-state condition by day 45; more importantly, the event execution never happens. Despite changing the parameters several times, the simulation never produced a TSE event execution. Therefore, the event execution outflow was redesigned and included as part of model 5C.

4.5.2 Model 5B. Model 5B created a single variable for political will and applied a smoothing function to account for trends in behavior over a 30-day time period. This means that the political will reacts to the 30-day trend of TSE impact change. The change in model structure can be seen by comparing the government sector in Figure 33 with the government sector of Figure 36 in Section 4.5.4. However, since the model still does not execute a TSE event, the TSE impact value is zero and, therefore, the political will is zero. If the TSE trend variable, which is based on the TSE impact variable, is of large enough magnitude, the political will of the nation will cause an increase or decrease in government spending to match that trend. Model 5B also made a small correction to the terrorist visibility variable. The terrorist visibility function was expanded to include a terrorist daily activity stock term. The justification for this change was that terrorist visibility is based on all terrorist activity and not just TSE activity.

4.5.3 Model 5C. Model 5C addresses the need to make the mechanistic outflow more realistic by incorporating a smoothing function and a variable to monitor the first-order derivative of the smoothing function. The theory is that if the terrorist leadership saw zero or negative growth in their significant event activities, they would execute their

attack early before losing their stockpiled assets. The basic design for this new outflow is to empty the entire TSE stock at once if the stock reaches the goal or if the stock trend takes on a negative growth rate (i.e. signifying a loss of stockpiled assets). This function operates on 4 variables (SE resource, outflow rate, SE resource trend slope, and SE resource trend) and two parameters (goal and SE resource trend interval). This new outflow corrected the previous problem. However, after model 5C was developed and tested, it was recognized that it did not adequately describe the system behavior. For instance, the terrorist significant event stock was not refilling as expected and the government expenditures were growing at an exponential rate beyond what the U.S. government was capable of spending.

4.5.4 Model 5D. Model 5D corrected the shortcomings of model 5C. The most obvious error was that the primary inflow variables going from terrorist daily activities to terrorist significant events did not have any kind of conversion factor. If a terrorist group trains an individual in how to make bombs or how to fire a weapon, the inherent value of that training is greater than the costs directly associated with the training itself. Similarly, the overall value of those assets will be greater (or less) than the actual value for which they were purchased. Based on these assumptions, amplification factors (parameters) were added to terrorist training, planning, and logistics.

Another error was that there were no limits on the U.S. government's capability for spending on counterterrorism efforts. Utilizing the same method used to simulate the outflow for the terrorist significant event stock, a smoothing function was set up for the daily government expenditures stock with a variable monitoring the derivative of the

trend slope. If the government daily spending trend exceeds some parameterized threshold amount, an elevated, or threshold pressure, is applied to control the spending.

Model 5D also provided additional modifications to the political will variable so that negative political will was possible if there was a significant decrease in terrorist activity over an extended period of time. This change simply required separate calculations for the magnitude and direction of political will. The equations for model 5D and the model data used during the simulations can be found in Appendix C. Figure 36 shows the final model structure, and Figure 37 shows the initial simulation output of the final model.

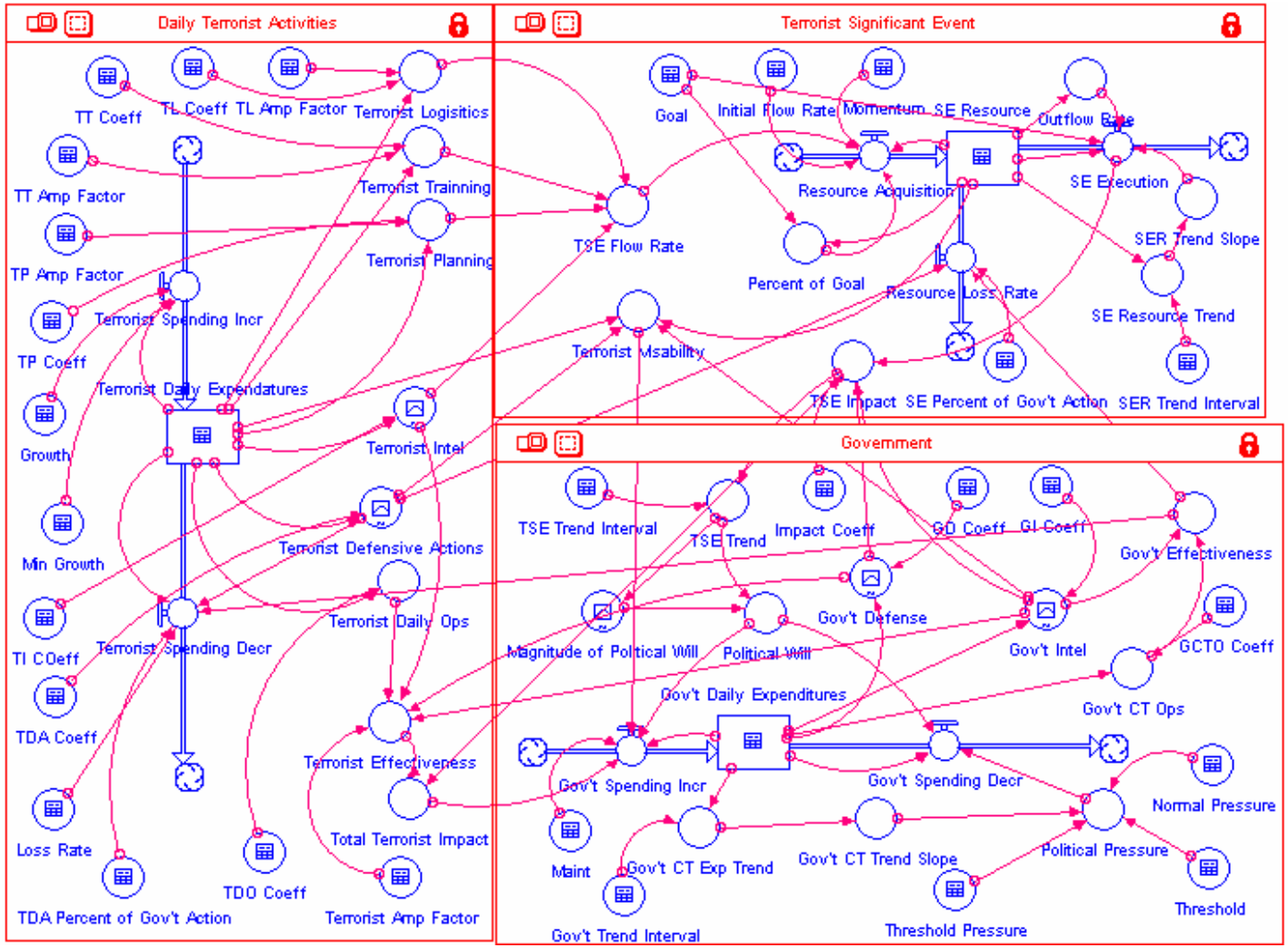


Figure 36. Stella® Model 5D Final

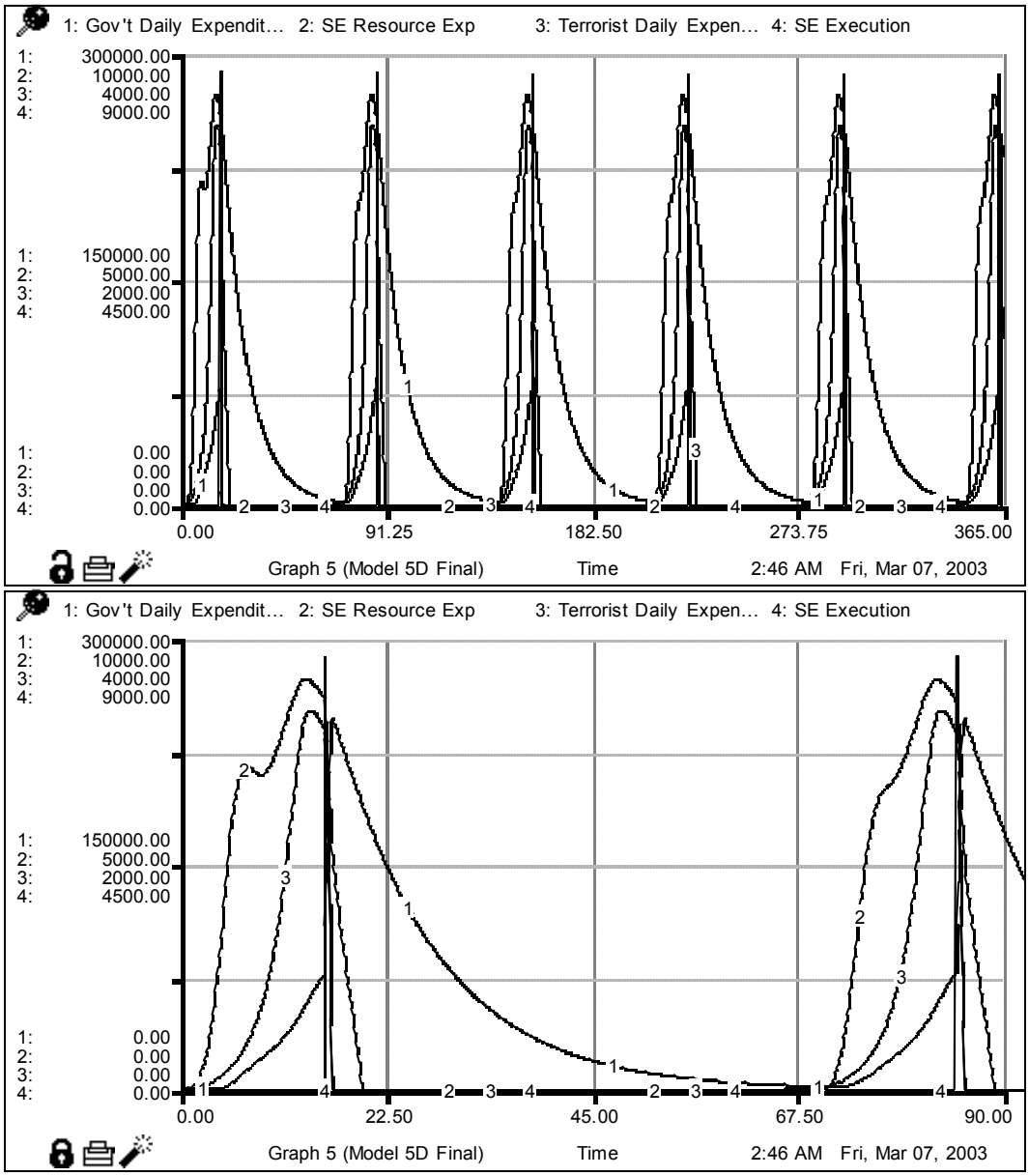


Figure 37. Stella® Model 5D Final – Initial Output

Top – Full Run (365 days); Bottom – Single Peak (90 days)

4.6 Final Model Parameters

The values currently used in the final model are educated guesses that have not been rigorously justified. The final model parameters have been divided into three categories: model assumptions, fixed parameters, and estimated parameters.

4.6.1 Model Assumptions. The final model has 16 model parameters that are based on assumptions, which are summarized in Tables 4 and 5. These 16 model assumptions are broken up into two categories: 11 terrorist assumptions and 5 government assumptions. These two categories are explored in sections 4.6.1.1 and 4.6.1.2, respectively. Many of these assumptions will be discussed further in Chapter 5 as areas for future research.

Table 4. Summary of Model Parameters – Terrorist Assumptions

Model Parameter	Model Section	Value	Basic Assumption
Terrorist Daily Expenditures	DTA	\$0/day	When the terrorist organization is created they have no stockpiled assets
Growth	DTA	50%	A terrorist organization over its lifespan averages 50% growth on their stockpiled assets after they start stockpiling them
Loss Rate	DTA	1%	A terrorist organization wastes 1% of their assets
Minimum Growth	DTA	\$10/day^2	A terrorist group raises at minimum \$10/day^2
Terrorist Logistics Amplification Factor	DTA	100	A terrorist group averages \$100 of value from every \$1 spent on logistics
Terrorist Planning Amplification Factor	DTA	100	A terrorist group averages \$100 of value from every \$1 spent on planning
Terrorist Training Amplification Factor	DTA	100	A terrorist group averages \$100 of value from every \$1 spent on training
Terrorist Amplification Factor	DTA	100	A terrorist group averages \$100 of value from every \$1 spent on daily operational related activities
Significant Event Resource Expenditures	TSE	\$0/day	When the terrorist organization initiates a terrorist action they have no stockpiled assets
Momentum	TSE	50%	The act of stockpiling assets for an attack has an associated 50% momentum that increases the terrorists ability to collect additional assets
Initial Flow Rate	TSE	\$1/day	Inherently, the terrorist has a need to attack. This need is represented by the \$1/day^2 initial and constant flow rate

Table 5. Summary of Model Parameters – Government Assumptions

Model Parameter	Model Section	Value	Basic Assumption
Government Daily Expenditures	Government	$0/day	Initially Government does not spend money to fight terrorism unless there is a need
Impact Coefficient	Government	10,000	When a terrorist group initiates a terrorist attack they get $10,000 of damage for every $1 spent on the attack
Maintenance	Government	1%	Once the Government starts spending money on something there is a constant 1% inflow required to maintain those actions
Threshold Pressure	Government	50%	If the government spending to fight terrorism exceeds the threshold of acceptable spending Congress will reduce the spending by half
Normal Pressure	Government	10%	On any given day Congress wants to spend 10% of the counterterrorism funding on their unrelated pet project

4.6.1.1 Terrorist Assumptions. This study made assumptions about the stock, growth, and amplification. The simplest of these assumptions are the stock assumptions. It was assumed that the terrorists do not initially have any assets and that they must acquire all required assets. These assets are measured by how much the terrorist spends to acquire and/or to train the asset. It is assumed that both the terrorist daily expenditures stock and the significant event resource expenditures stock both start at $0/day and $0, respectively.

The growth assumptions are necessary since this study does not model terrorist fundraising activities. As with most investments, it was assumed that the terrorists

benefit from some type of growth or momentum associated with the acquisition of assets. In the TDA sector of the model, the growth parameter was associated with an increase in daily terrorist expenditures. It was assumed that the terrorist organization generates a flow each day that is equal to 50% of its current stockpiled assets. Because of this and the assumption that the initial stock value is zero, a minimum growth or minimum fundraising amount had to be identified to initiate the terrorist activity. This was assumed to be $\$10/day^2$. Opposite of growth, a loss rate was identified for the daily terrorist expenditures outflow; it was assumed that terrorists waste one percent of their stockpiled assets. In the TSE sector, momentum was assumed to be 50%; in other words, for every $2 worth of assets currently stockpiled, $1 worth of new assets were generated. A flow rate of $1/day was initially added to the model to initiate the process of accumulating assets for an attack. However, as identified earlier, it is no longer required for the model and can be dropped in later research.

The amplification factor assumptions have to do with the gained value provided by an activity. For example, if the amplification factor was $10, the organization would gain $10 in value for every $1 spent on that activity. The final model has four amplifications factors associated with the daily activities of terrorists: terrorist logistics amplification factor (TL Amp Factor), terrorist planning amplification factor (TP Amp Factor), terrorist training amplification factor (TT Amp Factor), and terrorist amplification factor. Terrorist logistics, planning, and training were identified as primary TDA variables associated with the TSE activities of the terrorist organizations. All four of the terrorist amplification factors were arbitrarily assumed to be 100.

4.6.1.2 Government Assumptions. There are five government assumptions: government daily expenditure, impact coefficient, maintenance, threshold pressure, and normal pressure. The government daily expenditure stock was initially set to zero for the same reason that the two terrorist stocks were set to zero. The assumption is that the government did not have inherent counterterrorism assets identified to address the problem and that they had to relocate the required assets from other government activities or procure them. Another similarity to the terrorist side of the model is the impact coefficient, which is similar to the terrorist amplification factors. The impact coefficient is a conversion factor that changes the dollars spent by the terrorist group on a TSE attack into the amount of damage inflicted on the target of the attack. This value is assumed to be 10,000. For every $1 spent on the attack by the terrorist group, $10,000 of damage is inflicted on the target. The maintenance parameter is a growth assumption based on the government's requirement to maintain their organizations and facilities. This parameter was assumed to be 1% of the current stock.

The last two parameters are political pressures associated with the government outflow. The threshold pressure represents a higher political pressure to control government spending that exceeds the threshold value. It was assumed that the threshold pressure was 50%; in other words, politicians diverted half of the governments counterterrorism spending to other government programs because of out of control spending. The normal pressure parameter represents the daily pressure from Congress to spend money on things other than counterterrorism. It was assumed that normally 10% of all government counterterrorism spending was being diverted to other government activities.

4.6.2 Fixed Parameters. There are four fixed parameters, three of which are trend intervals. Table 6 gives an overall summary of these fixed parameters and justification for their values. Trend intervals are parameters required by Stella® to identify the time units used in evaluating the trend of the variable of interest. The SE resource (SER) trend interval is the number of days that terrorist leaders want to look back to evaluate their stockpiling of resources in the preparation for a TSE attack. Since TSE decisions are concerned with short term decisions, the interval was set at 2 days. This parameter is primarily concerned with how soon after the government starts to drain off stockpiled TSE resources are the terrorists going to execute the TSE event before all assets are lost.

Table 6. Summary of Model Parameters – Fixed

Model Parameter	Model Section	Value	Justification
SER Trend Interval	TSE	2 days	Did they do better or worse today than yesterday
Government Trend Interval	Government	30 days	Government operates on monthly, quarterly, and yearly data. This model utilizes monthly.
Threshold	Government	$1 billion/day	In 2002 the U.S. Government outlay for National Defense was just shy of $1 billion/day
Terrorist Significant Event Interval	Government	30 day	Government operates on monthly, quarterly, and yearly data. This model utilizes monthly.

The other two trend intervals, the government trend interval and the TSE interval, are related to governmental decisions. The government trend interval is used to decide if the government is spending too much on terrorism instead of other government agendas. The TSE interval is used to calculate the political will of the nation towards terrorism. Since the government normally operates on a monthly, quarterly, or yearly basis with its decision statistics, the interval for both parameters was fixed at 30 days. Quarterly or yearly trend analysis would make more sense if the model run time was greater than 1 year.

The threshold parameter is the point at which the political pressure to spend government money on other things significantly increases. For this model, the threshold was set at $1 billion/day for a 30-day trend. This was based on the $348,555 million in government outlays spent on national defense for 2002 (Office of Management and Budget, 2003:51).

4.6.3 Estimated Parameters and Sensitivity Analysis. As previously mentioned, the final model has 11 estimated parameters; except for the terrorist significant event sector, these parameters are based on percentages of activity or spending per day. Stella® was used to check the sensitivity of these parameters for three of the model's major decision points for system managers: government action, terrorist spending, and government spending. Table 7 summarizes the estimated parameters along with their model sector, their expected range, and their set value used for the sensitivity analysis of the other two parameter groups. As discussed in the following sections, the model demonstrated sensitivity to variations in each of the three parameter groups.

Table 7. Summary of Model Parameters – Estimated

Model Parameter	Model Sector	Expected Range	Value in Analysis of other Parameters
TDA Percent of Government Action	TDA	10-90%	Linked with SE Coeff. Otherwise 50%
SE Percent of Government Action	TSE	10-90%	Linked with SDE Coeff. Otherwise 50%
Terrorist Defensive Actions Coefficient	TDA	10-50%	Linked to Terrorist Coeffs Otherwise 10%
Terrorist Daily Operations Coefficient	TDA	10-50%	Linked to Terrorist Coeffs Otherwise 10%
Terrorist Intelligence Coefficient	TDA	10-50%	Linked to Terrorist Coeffs Otherwise 15%
Terrorist Logistics Coefficient	TDA	10-50%	Linked to Terrorist Coeffs Otherwise 15%
Terrorist Planning Coefficient	TDA	10-50%	Linked to Terrorist Coeffs Otherwise 25%
Terrorist Training Coefficient	TDA	10-50%	Linked to Terrorist Coeffs Otherwise 25%
Goal	TSE	1000-1000000	10000
Government Counterterrorism Operations Coefficient	Government	10-80%	Linked to Gov't Coeff. Otherwise 60%
Government Defense Coefficient	Government	10-80%	Linked to Terrorist Coeff. Otherwise 25%
Government Intelligence Coefficient	Government	10-80%	Linked to Terrorist Coeff. Otherwise 15%

4.6.3.1 Government Action Decision. The government action consists of the following parameters: TDA Percent of Government Action and SE Percent of Government Action. These parameters target a percentage of the total amount of government action towards terrorist daily expenditures or terrorist significant event resources, respectively. Because these parameters measure a percentage of the same activity, their sum must equal 1.0. If parameter values are in increments of 10, Table 8

provides the values used for both parameters as part of the sensitivity analysis. The results are shown in Figures 38, 39, and 40 for each of the model stocks.

Table 8. Sensitivity Settings for the Government Action Parameter Group

Run	SDE Percent of Government Action	SE Percent of Government Action	Total
1	10	90	100
2	20	80	100
3	30	70	100
4	40	60	100
5	50	50	100
6	60	40	100
7	70	30	100
8	80	20	100
9	90	10	100

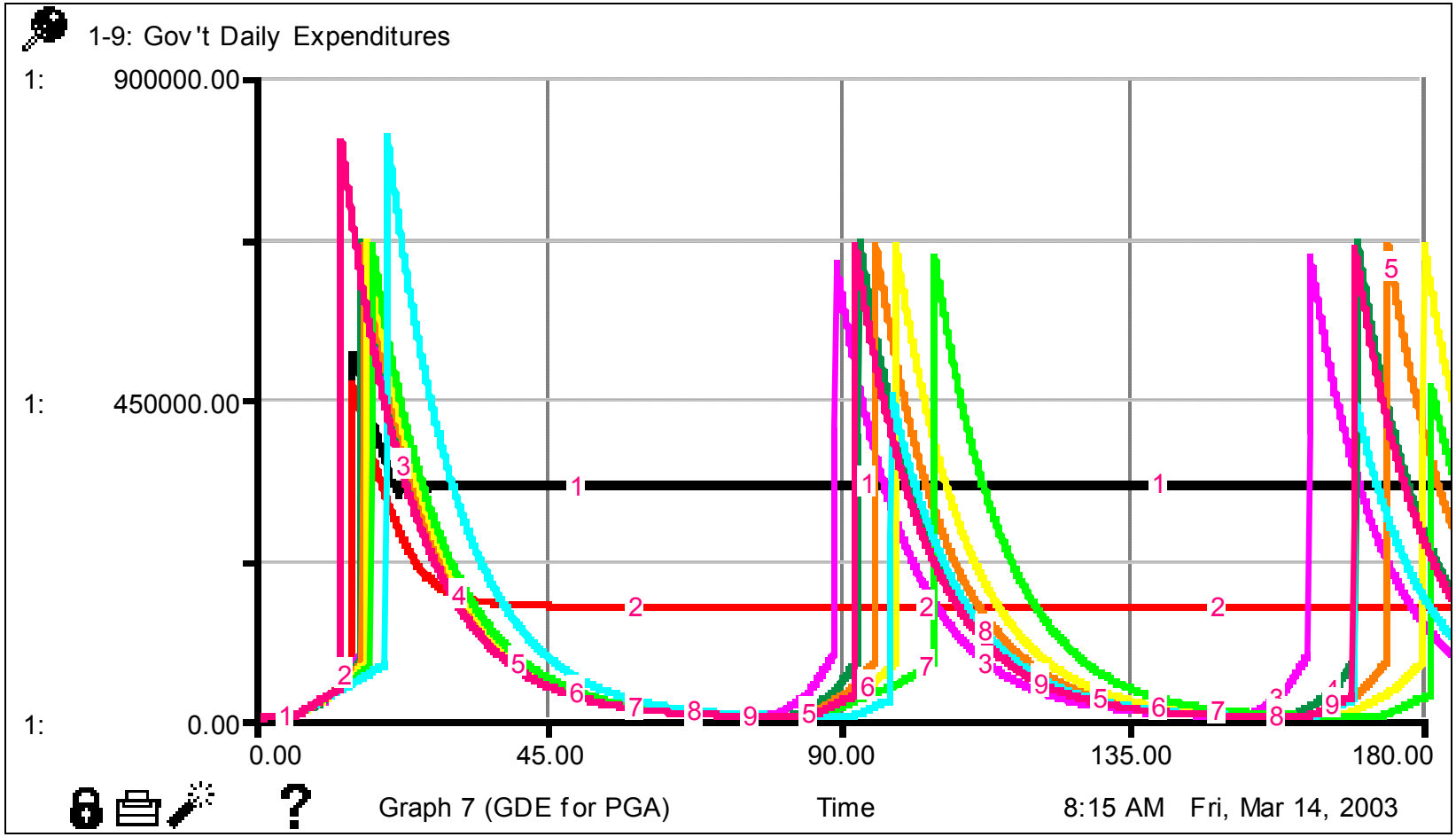


Figure 38. Government Daily Expenditures Sensitivity to Government Action Parameter Group

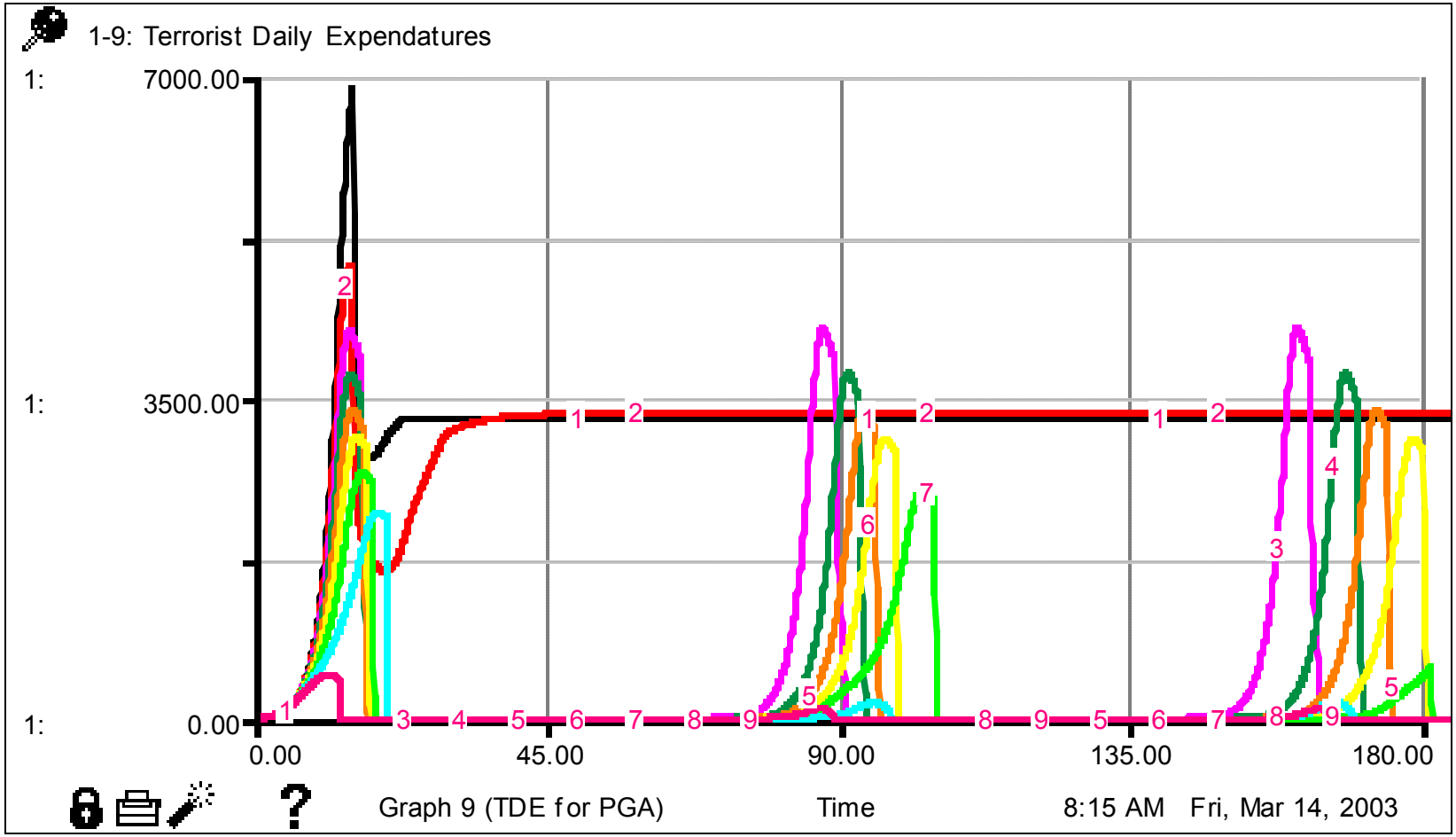


Figure 39. Terrorist Daily Expenditures Sensitivity to Government Action Parameter Group

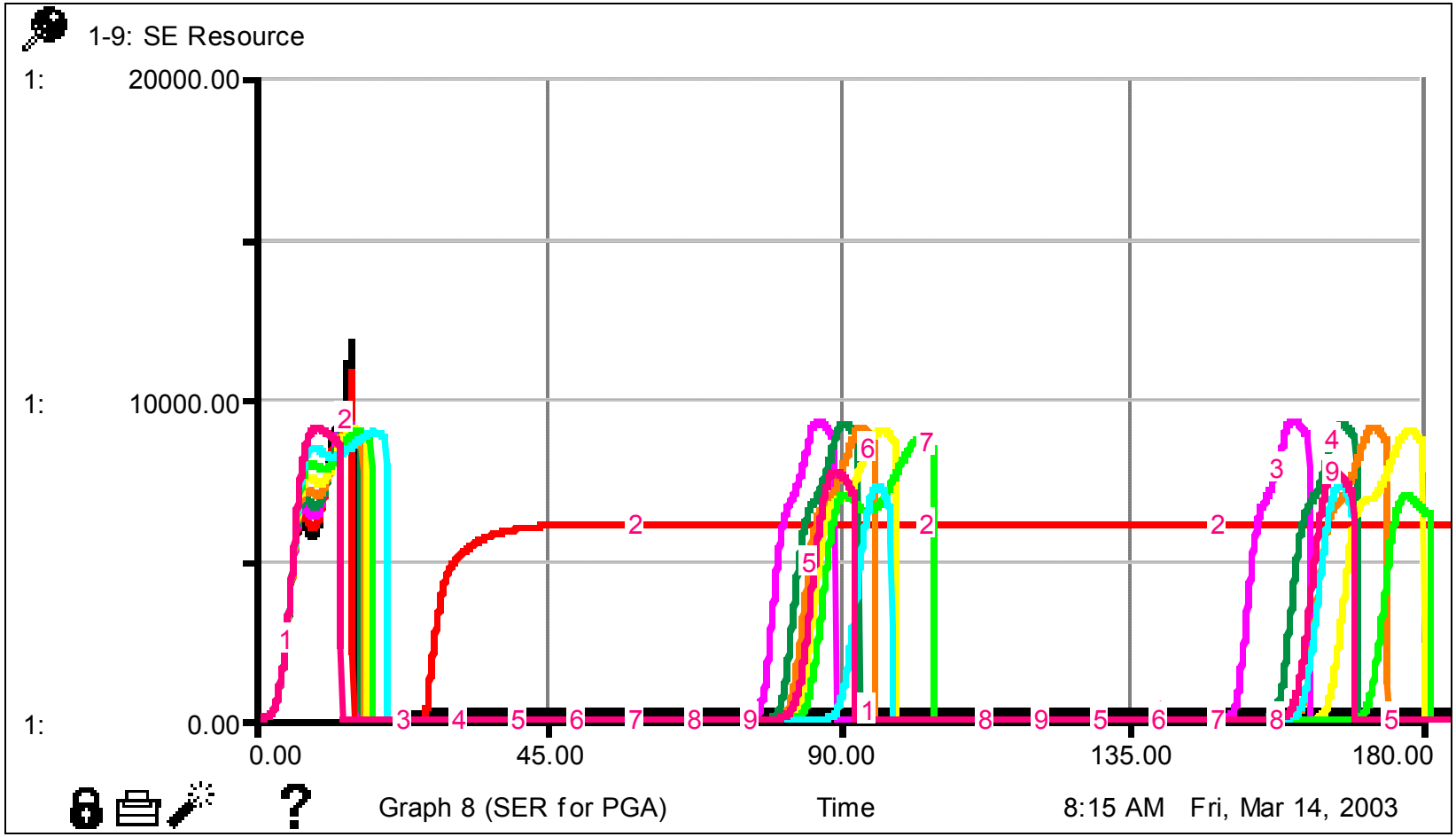


Figure 40. Significant Event Resource Sensitivity to Government Action Parameter Group

Of the nine sets of parameter values shown in Table 8, only two runs result in significant behavioral changes to the simulation output: run 1 and run 2. According to these two runs, the modeled system as currently defined reaches steady-state behavior when 80 percent or more of the total government actions focus on the terrorist significant event sector of the model. As indicated in Figures 38 through 40, the remaining sets of parameter values demonstrate an oscillating behavior with variations in the amplitude and frequency of the oscillations.

4.6.3.2 Terrorist Spending Decision. With six parameters in this section, this was the most complicated sensitivity analysis of the model. The six parameters involved were the terrorist defensive action (TDA) coefficient, terrorist daily operations (TDO) coefficient, terrorist intelligence (TI) coefficient, terrorist logistics (TL) coefficient, terrorist planning (TP) coefficient, and terrorist training (TT) coefficient. These parameters measure what percentage of the terrorist activity is spent in each area; therefore, the sum of all six variables must equal 1.0. A key assumption for this section was that each parameter would have a minimum value of 0.10, assuming that each activity would represent at least 10 percent of the terrorist's total daily activity. Because many of the parameters have not been justified with real-world data, the sensitivity analysis was limited to the values shown in Table 9 as an example of the possibilities. The results for these seven combinations are illustrated in Figures 41, 42, and 43. As the figures indicate, the seven combinations are similar, with significant differences only in the amplitude and frequency of the oscillations. Some of the results indicate such low oscillation amplitudes after the initial spike that they are effectively zero. When the

model parameters have been more robustly defined, the full scale sensitivity analysis can be performed.

Table 9. Sensitivity Settings for the Terrorist Spending Parameter Group

Run	TDA Coeff %	TDO Coeff %	TI Coeff %	TL Coeff %	TP Coeff %	TT Coeff	Total
1	50	10	10	10	10	10	100
2	10	50	10	10	10	10	100
3	10	10	50	10	10	10	100
4	10	10	10	50	10	10	100
5	10	10	10	10	50	10	100
6	10	10	10	10	10	50	100
7	16.67	16.67	16.67	16.67	16.67	16.67	100.02

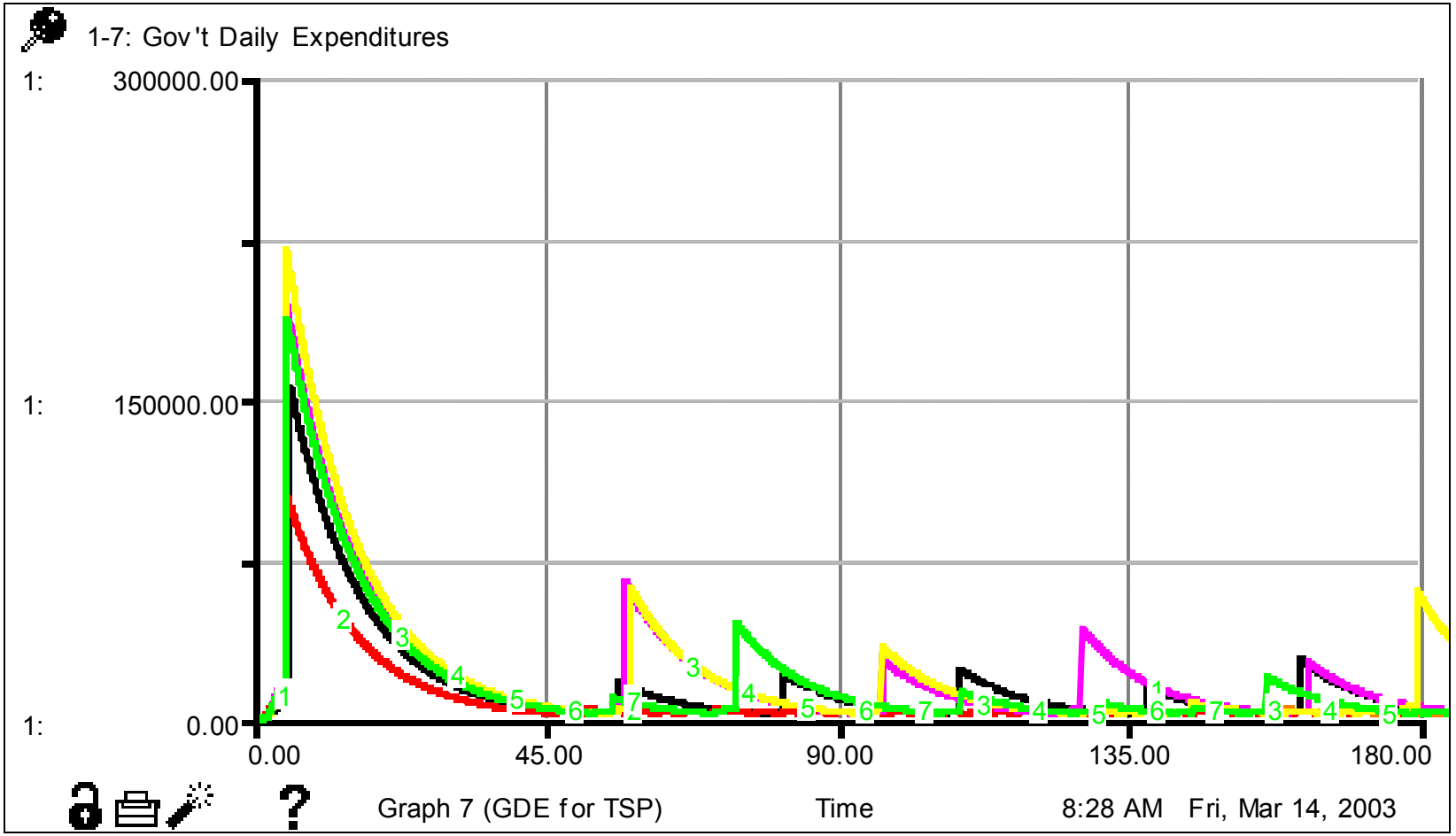


Figure 41. Government Daily Expenditures Sensitivity to Terrorist Spending Parameter Group

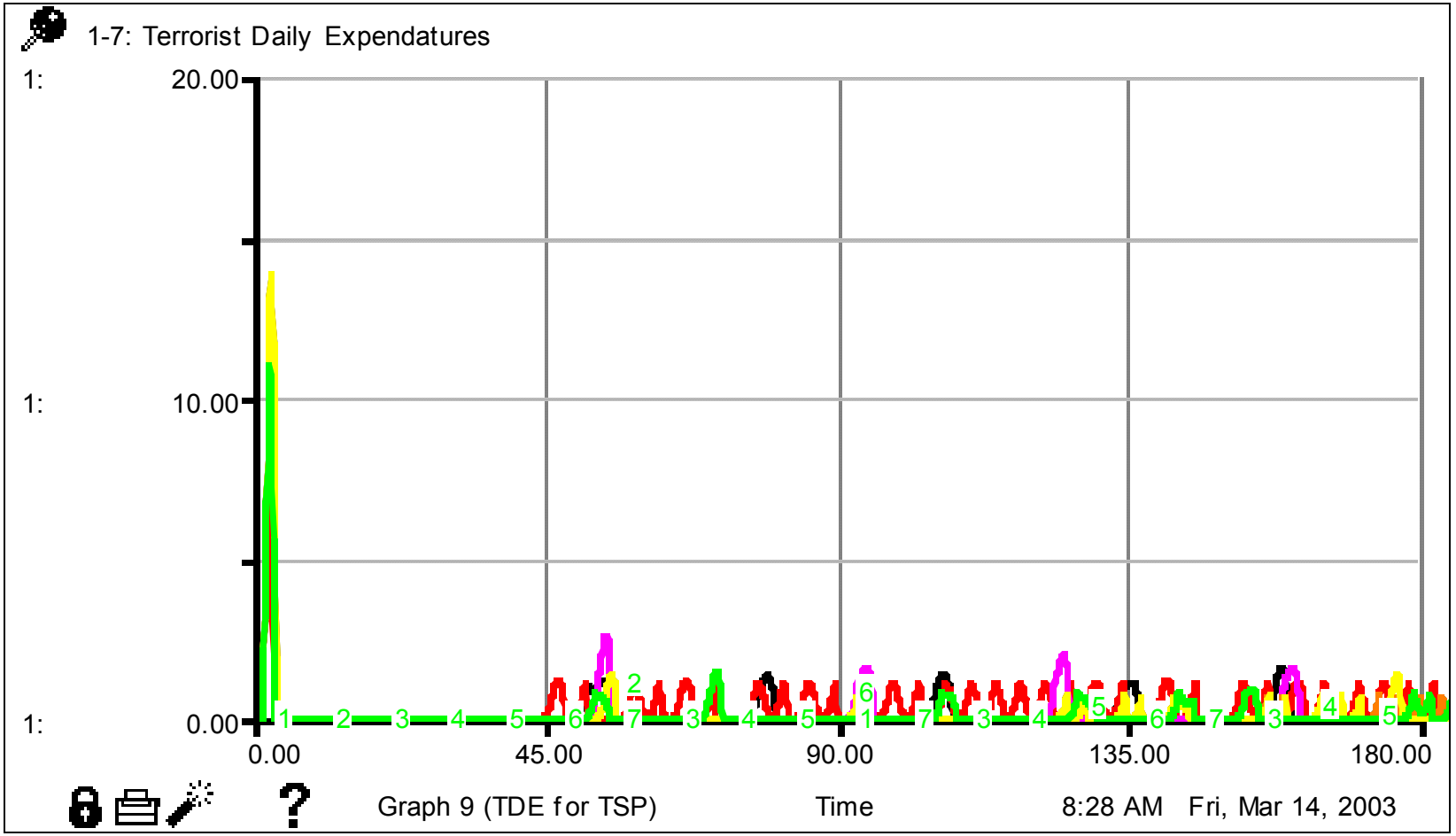


Figure 42. Terrorist Daily Expenditures Sensitivity to Terrorist Spending Parameter Group

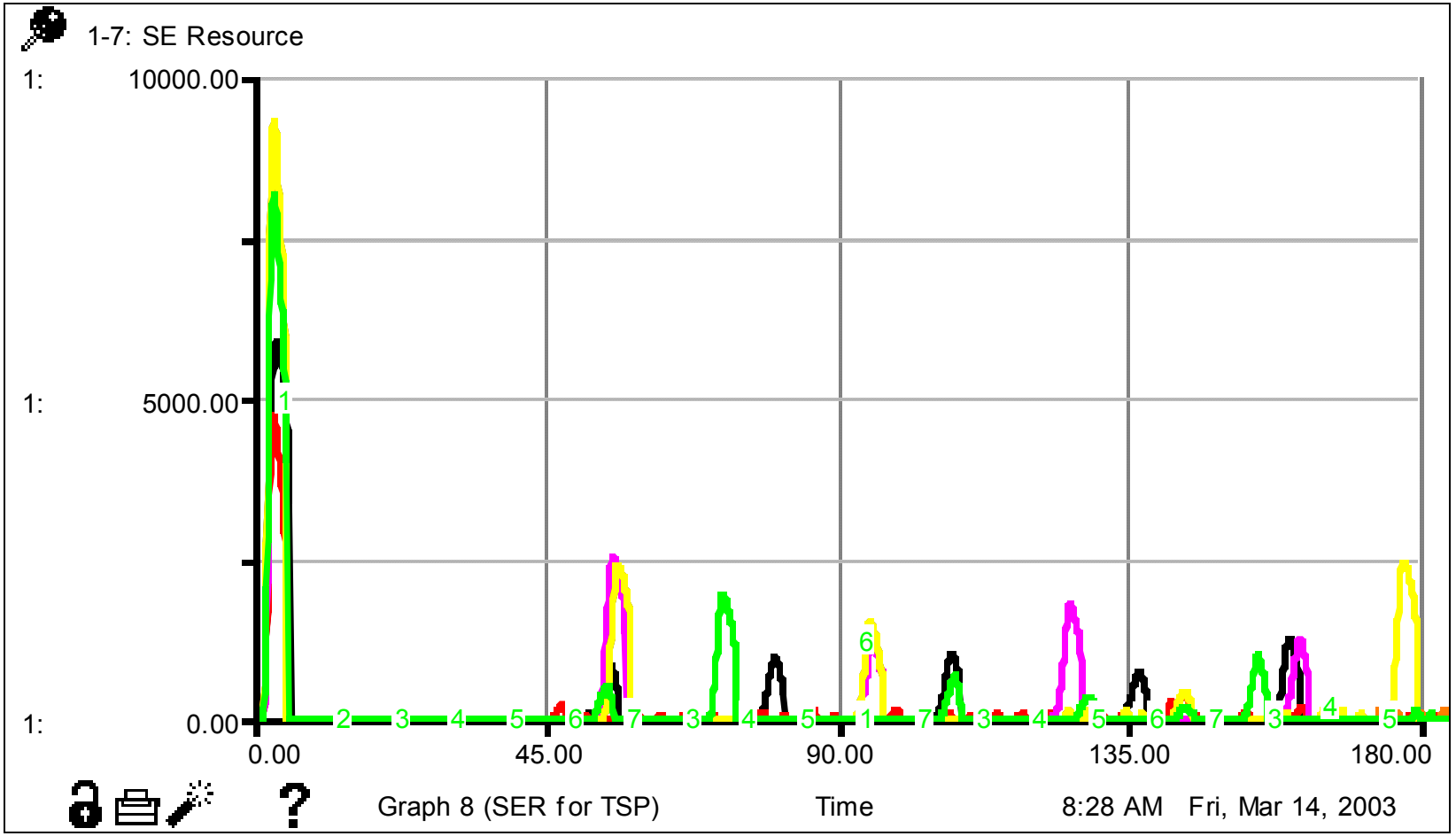


Figure 43. Significant Event Resource Sensitivity to Terrorist Spending Parameter Group

4.6.3.3 Government Spending Decision. Government policy dictates how the government spends its money. The parameters associated with government policy include the government counterterrorism operations (GCTO) coefficient, the government defense (GD) coefficient, and the government intelligence (GI) coefficient. GCTO refers to offensive government actions against terrorist's assets and activities, whereas GD refers to active and passive defensive government actions implemented to protect government assets from terrorist attack. As with the previous two groups of parameters, the government spending parameters must sum to 1.0. The assumption was that each activity would require at least 10 percent of the government's total daily activity. Like the terrorist spending sensitivity analysis, this sensitivity analysis was limited to the values shown in Table 10 an example of the possibilities for government policy decisions. The results for these nine combinations are shown in Figures 44, 45, and 46. As the figures indicate, certain model parameters in this group have a rather large impact on the system behavior. Most notable is the GTCO coefficient which significantly limits model behavior when the GTCO is high.

Table 10. Sensitivity Settings for the Government Spending Parameter Group

Run	GCTO Coeff %	GD Coeff %	GI Coeff %	Total
1	80	10	10	100
2	10	80	10	100
3	10	10	80	100
4	70	20	10	100
5	70	10	20	100
6	20	70	10	100
7	10	70	20	100
8	20	10	70	100
9	10	20	70	100

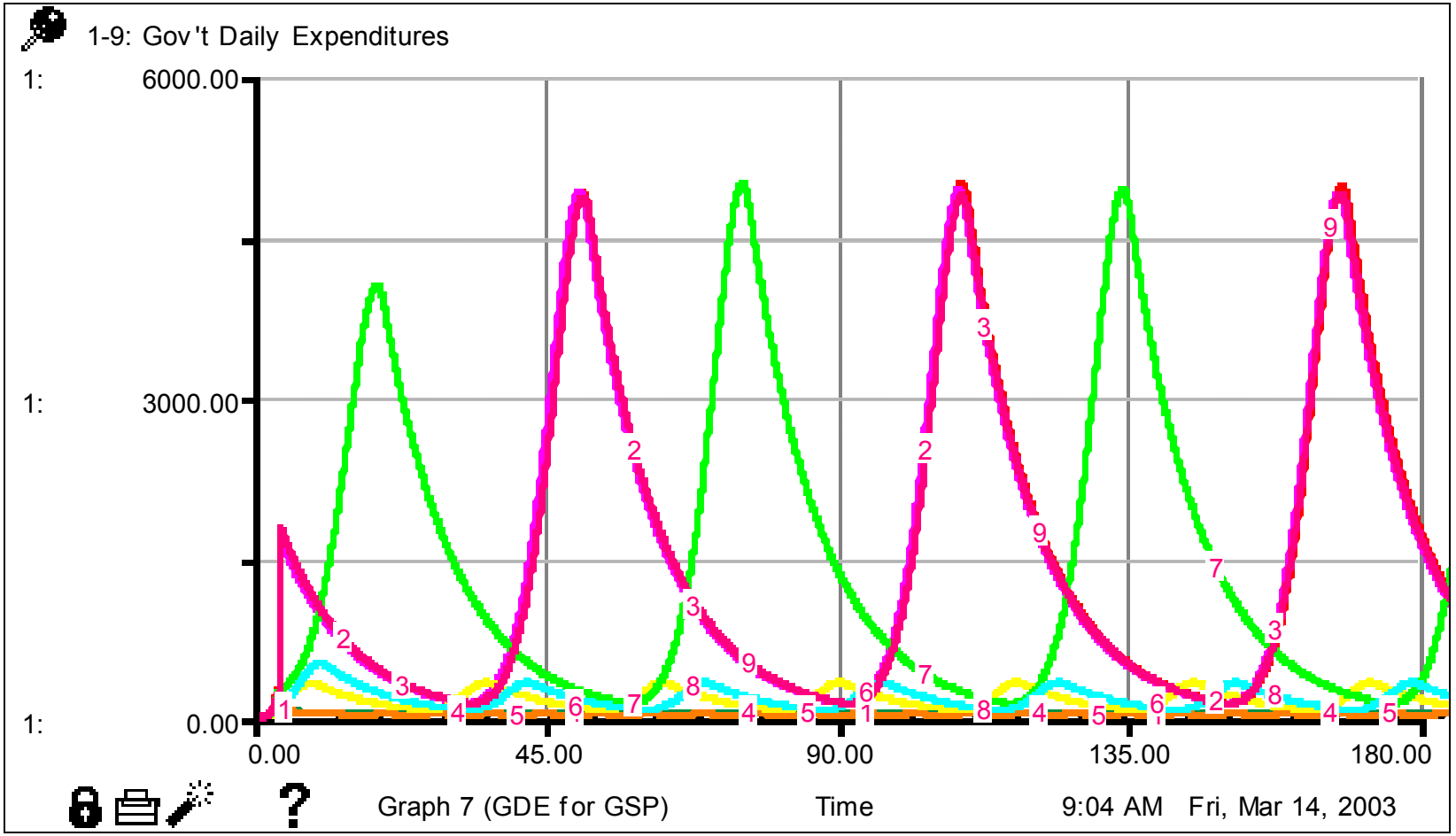


Figure 44. Government Daily Expenditures Sensitivity to Government Spending Parameter Group

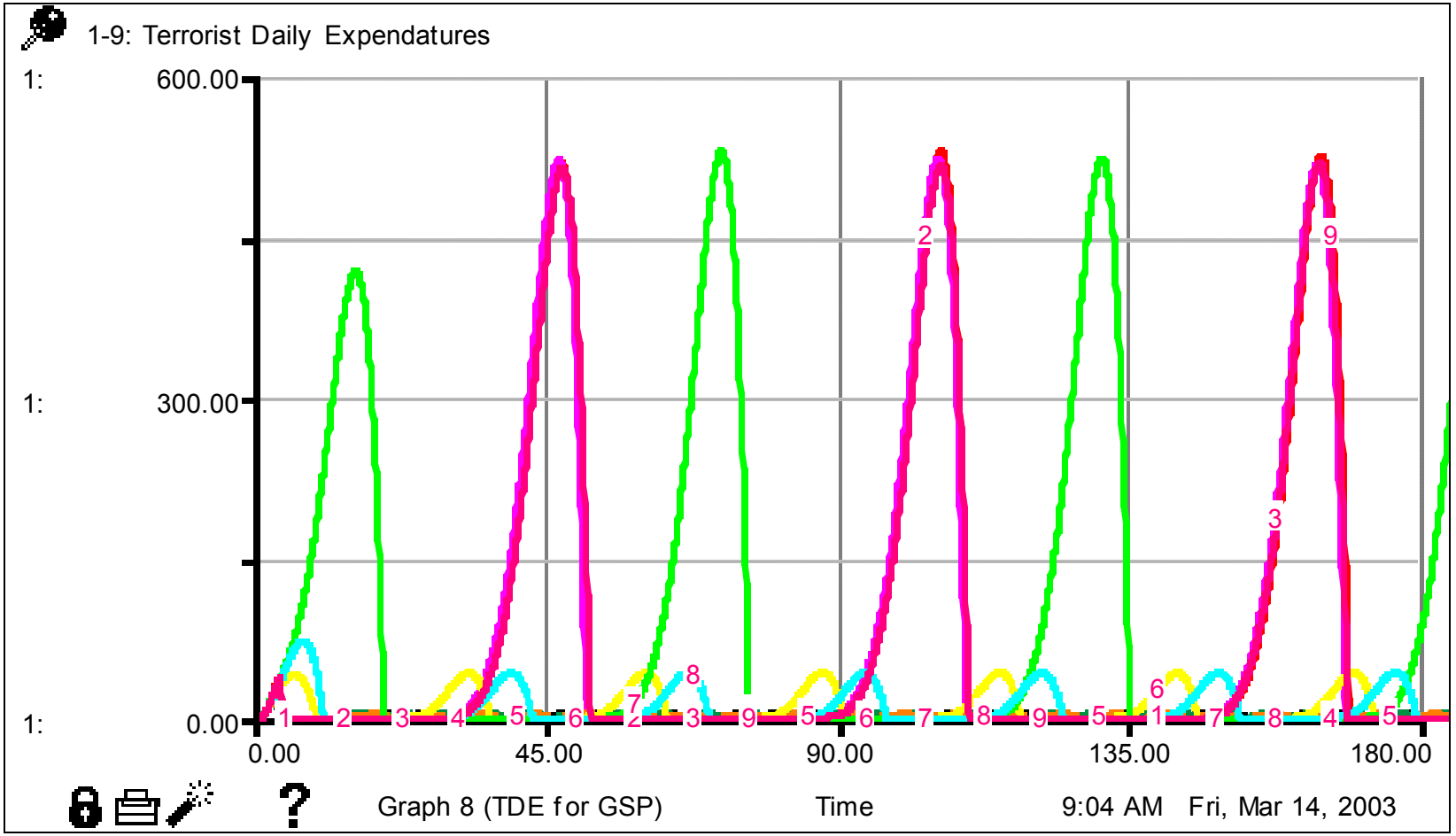


Figure 45. Terrorist Daily Expenditures Sensitivity to Government Spending Parameter Group

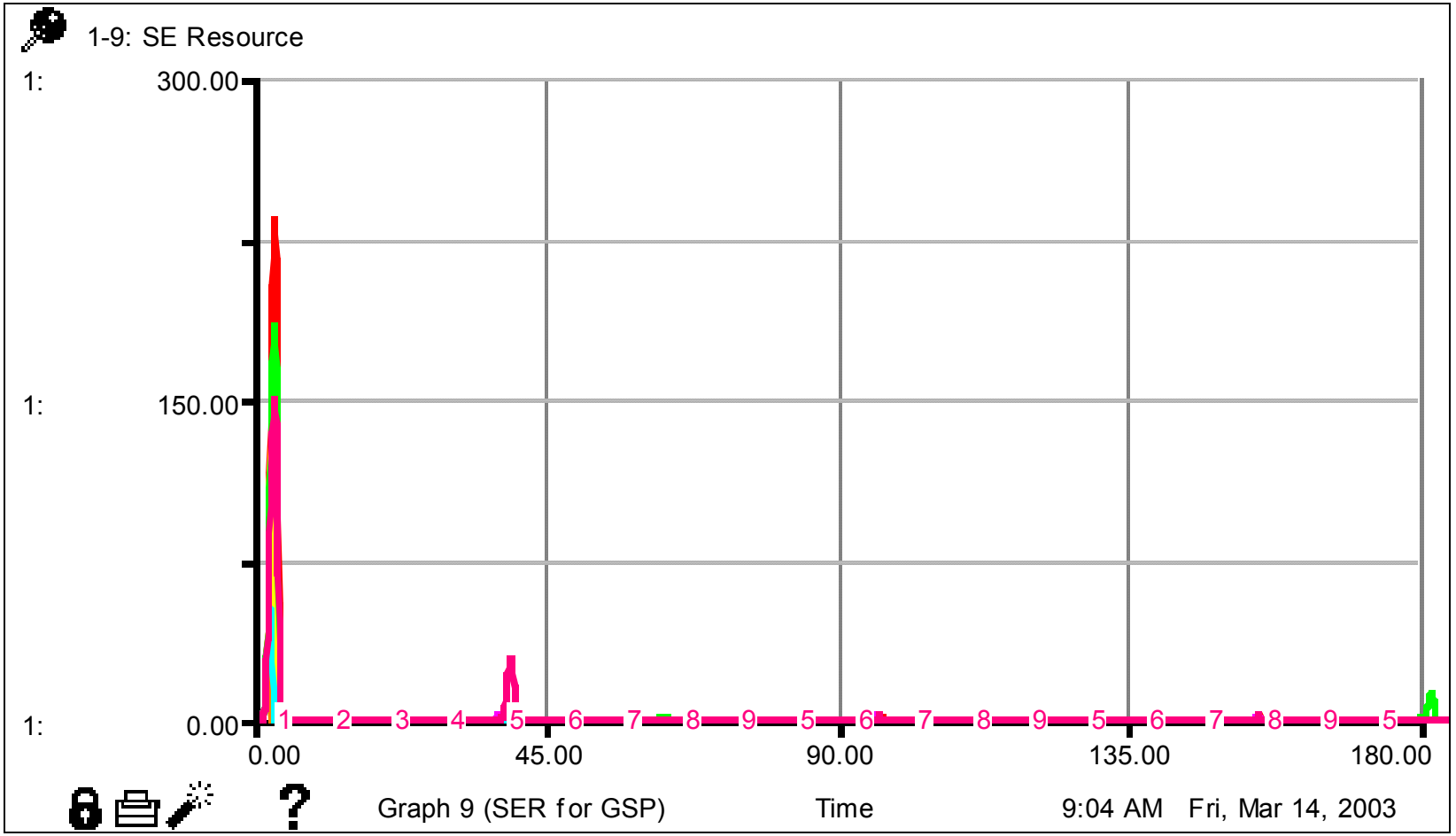


Figure 46. Significant Event Resource Sensitivity to Government Spending Parameter Group

4.6.4 Graphical Variables. The last section of this chapter explains the five graphically defined variables shown in Figure 47: government intelligence, government defense, terrorist intelligence, terrorist defense, and magnitude of political will. The data points used to create the graphs for these variables are included in Appendix C. Except for political will, the variables are similar in nature. Each one produces an efficiency rating, ranging from 0 to 1, based on how much money is being spent on that variable by the government or the terrorist. This efficiency rating is used by other variables in the model to determine how much of a given action was effective. For example, suppose the government spent $1 million/day in GCTO. However, the government intelligence variable said that the government only knew 50 percent of what the terrorists were doing. This would be represented by a rating of 0.5, which would indicate that only $0.5 million/day was spent. The other 50% of the money was wasted on useless actions.

Each of these four variables also have a defined upper and lower boundary; within these bounds, their behavior follows an S-shaped curve. It is assumed that regardless of how much is spent, one can never know or defend against everything; therefore, the upper boundaries are 80 percent for the government and 90 percent for the terrorists. The lower bounds are considered to be zero except for the two intelligence variables. It is assumed that even if no money is spent on intelligence, media coverage will provide a minimal level of intelligence; therefore, the lower bounds for terrorist and government intelligence are 25 percent and 16.5 percent, respectively. The lower bounds for the defensive variables were set at zero since one must take some kind of action to defend against an enemy action.

The fifth graphic variable, magnitude of political will, uses a step function to determine the level of political will. The idea behind this variable is that the political will of a nation is not linear. When the level of significant terrorist activity moves outside a set range, government political will causes either an increase or decrease in government spending to fight terrorism. This graphical variable calculates only the magnitude of change in political will; the change in direction, i.e., increase or decrease, is determined by the political will variable.

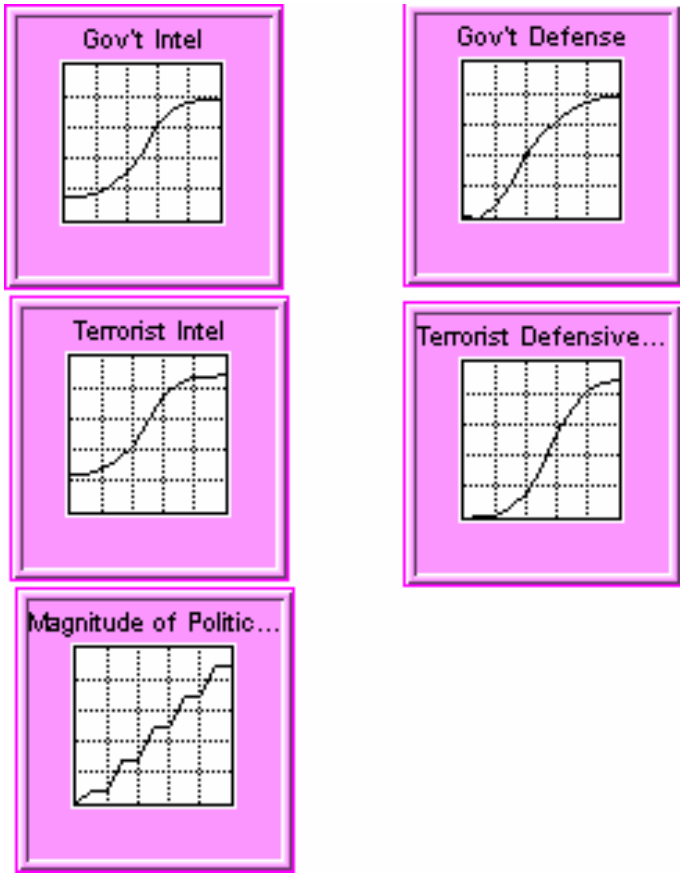


Figure 47. Graphic Variables

V. Conclusions

This research showed the ability of system dynamics to help develop a government policy towards terrorism that can directly affect a terrorist's behavior. The study had two objectives: (1) identify the primary interactions between terrorist organizations and the government and (2) provide insight into how the terrorist-government system behaves and what effects changes to the primary interactions have on the overall system behavior. Even with some significant limitations, the final model clearly demonstrates that there is a tremendous potential benefit to the government from this line of research. As demonstrated by the sensitivity analysis of the government parameters, the focusing of government action and the way the government spends its money can directly affect the behavior of the terrorist organization. From that perspective, this study identified more questions then it answered.

5.1 Objectives and Conclusions

5.1.1 Identifying the Primary Interactions. The study's inductive system dynamics approach and available literature on terrorism have established a final model of terrorist–government interaction that identifies some very significant system interactions between the three model sectors: terrorist daily activity, terrorist significant event, and government. These significant system interactions are at an aggregated level of government activity. These aggregated activities were supported with an intense literature review of the subject matter.

5.1.2 Basic Insight into the System Behavior and Primary System Drivers. The final model shows the benefit of certain types of aggregated government interactions with a terrorist organization that produce a more desired behavior for the overall system based on the model parameters. The sensitivity analysis highlights how the primary system interactions can drive the overall model behavior. This research effort is the genesis of a future research stream capable of helping the government manage their terrorism policy to produce the desired system behavior.

5.1.3 Conclusions. This study, even with its limitations, demonstrated that system dynamics is capable of providing government policy makers with key insights about how to approach terrorism from an aggregated level. It is clear that this current model suggests a government policy that favors offensive action against a terrorist organization. This supports the old axiom of human conflict that "the best defense is a good offense." There are real-world limitations that are currently part of this model that need to be considered in future research; however, sponsorship from the right governmental organizations and the proper access to data will produce a model that has significant implications in how the government approaches terrorism at an aggregate level.

5.2 Model Limitations

This model has several significant limitations that need to be addressed. These primary limitations have been classified into three categories: level of detail, parameter assessment, and general limitations. The level of detail limitation addresses the need or potential need for greater detail in certain parts of the model. The parameter assessment

focuses on the need for real-world data to parameterize the model. Finally, the general assumptions identify key real-world limitations to this model and modeling process.

There are two primary limitations related to level of detail in this study. First, the current model does not account for terrorist fundraising activities or government actions to target these activities. Chapter II identified that since September 11, 2001, the U.S. government has been leading an international effort to freeze known terrorist's assets and to cut of their funding sources. This demonstrates that the government considers terrorist fundraising to be a key interaction driving the overall system behavior. The current model needs to be expanded to test this belief.

The second limitation concerns the five graphical variables utilized within the current model. Each of these variables could be further defined with system dynamic structures on a sub-system level to better simulate the actual behavior produced by these variables. The most likely of these five variables for additional level of detail is the government variable for intelligence. The reason for this is the popular perception that there is a distinct difference between electronic intelligence and human intelligence and that the sub-system activity at this level will significantly affect the model.

The second limitation category is parameter analysis. This limitation is possibly the most significant limitation to the current model and also probably the easiest limitation to correct. This limited the study's ability to get access to a terrorism expert or to some of the terrorism databases, such as the ITERATE database which costs $50 per year for access (Mickolus, 2002:160) or the RAND Chronology of International Terrorism (Quillen, 2002b:300). If a sponsor, or funding in general, can be obtained to

gain access to this real-world information, the already significant impact of the current model can be increased dramatically.

The last limitation category addresses the general limitations that are part of the underlying assumptions of this study. The largest of these limitations is that this study deals only with one terrorist organization interacting with one government. In reality, most nations interact with more than one terrorist organization and most terrorist organizations interact with more than one government. However, at an aggregate level, many of the insights gained by the study can still be applied.

The other major limitation in this category is that system dynamics focuses on system behavior over time and not on trying to predict a system output for a given time. Therefore, this model is not capable of predicting the exact time or location for a terrorist attack. The current model does not incorporate a lot of terrorist decision making analysis about how, what, when, or where to attack. Even with these limitations, the general knowledge that is gained about the system behavior and how key elements of the system affect that behavior has a significant value to government policy makers.

5.3 Future Research Possibilities

This study has proven that system dynamics has a distinct future in helping government policy makers better understand the system behaviors driven by terrorist–government interactions. This creates significant possibilities for future research: model parameter justification, level of model detail, and spin-off research. However, this list of future research is by no means all inclusive. The terrorism field of research is relatively new to the U.S. academic community; however, the British and others have been

studying terrorism for some time. *The Studies in Conflict & Terrorism* journal, available on the electronic EBSCO research database, is an amazing source of research material for this field of study.

5.3.1 Model Parameter Justification. Justification of model parameters is the next logical step in this line of research. The data for the justification of these parameters can be collected in another research effort or purchased if funding becomes available. Additionally, the support of a terrorism expert would greatly help the justification effort and the overall modeling effort. However, the researcher also needs to keep in mind, "What question am I trying to answer, and what level of data do I need to get that answer?"

5.3.2 Level of Model Detail. Some thought needs to be given to expanding the level of detail for this model. As mentioned in earlier sections, the model currently has no structure associated with terrorist fundraising efforts. Both Gunaratna (2002:60-62) and Hoffman (2002:306-307) have credited Al Qaeda with having a sophisticated financial system. Hoffman (1998:84) identifies that the Palestinian Liberation Organization (PLO) is suspected to have had an annual income of around a half a billion dollars in the mid-1980s from their financial system. These factors, combined with the government's focus on terrorist fundraising, justify expanding the level of detail in the overall model to include terrorist fundraising.

Additional detail needs to be considered for the model's graphic variables. Overall, each of these variables could be removed and replaced with a sub-model to more accurately model their effects on the overall model. The four S-shaped models could be replaced with model structures similar to the early models developed in model series 4.

The current model can still be accurate with the graphical variables, if they are properly defined. The question is whether additional detail in this area of the model creates a better simulation.

5.3.3 Spin-off Research. From the literature review in Chapter II, the most interesting spin-off research possibility is how "lateral pressure" affects the motivation and sponsorship of terrorist groups. Wils, Kamilya, and Choucri (1998) concluded that the variables of "lateral pressure" theory create a number of reinforcing loops that can make it difficult to halt the level of violence and conflict (Wils, Kamilya, and Choucri, 1998:155). They also conclude that "lateral pressure" is how a government acquires the assets they need to maintain their current quality of life (Wils, Kamilya, and Choucri, 1998:155). So does the U.S. involvement in the Middle East in some way drive the interactions between some terrorists groups and the U.S.?

Appendix A. Model Series 2 Final Model: Model 2C

This appendix displays Model 2C in its entirety as developed using Stella® 6.0. Model 2C was the final product of the series 2 modeling process and was one of two starting points for the final model developed in model series 5.

A.1. Model 2C Interface Level

The interface level is too large to fit on one screen shoot so it is shown in Figures 48 and 49. Figure 48 shows the model settings for the simulation run, the graphical variables and general comments on the model. Figure 49 shows the stock and flow graphs generated by the model's simulation run. The model run time is 365 days; however the graphs have been produced for only the first 180 days.

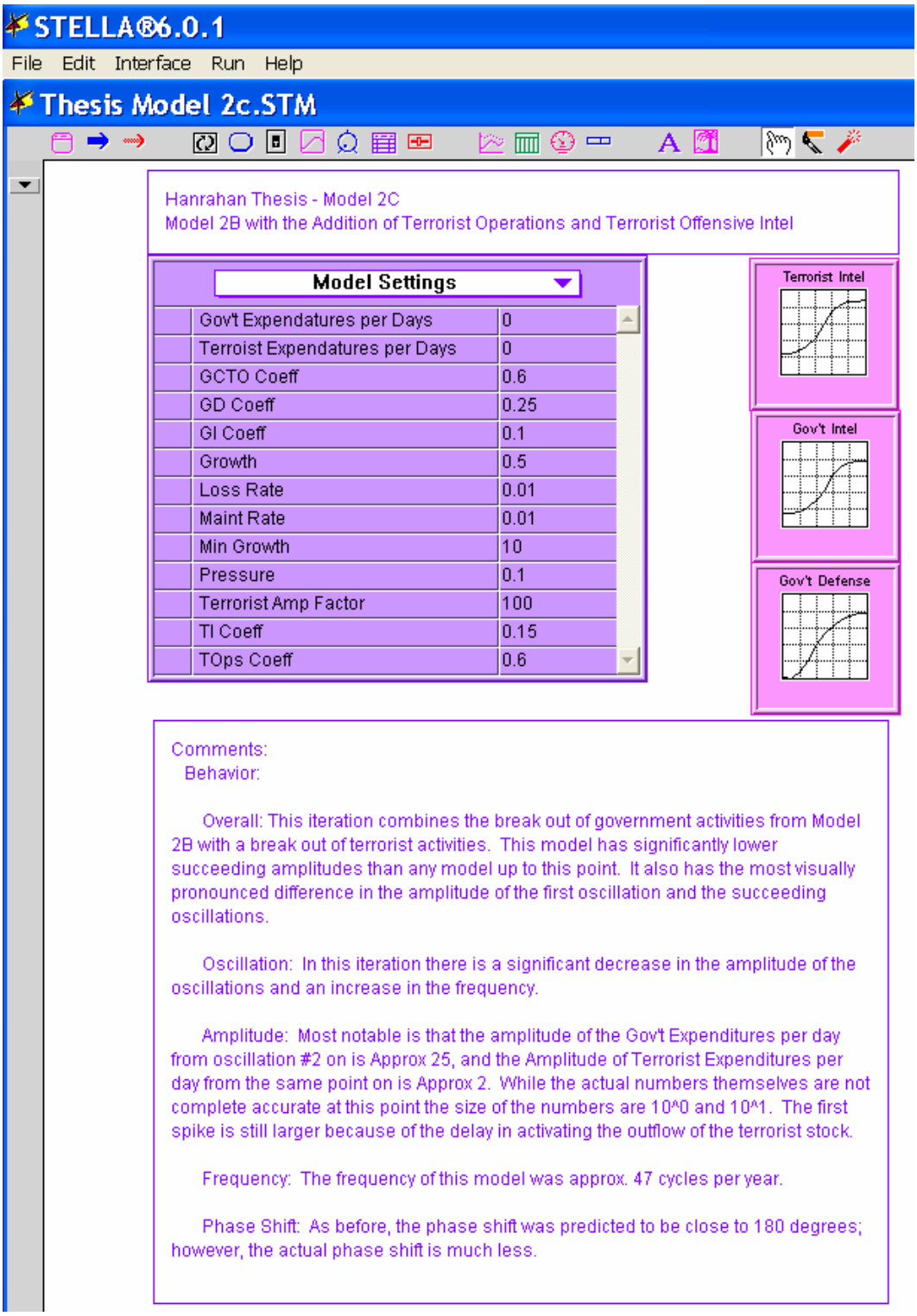


Figure 48. Model 2C Interface Level Screen Shot 1

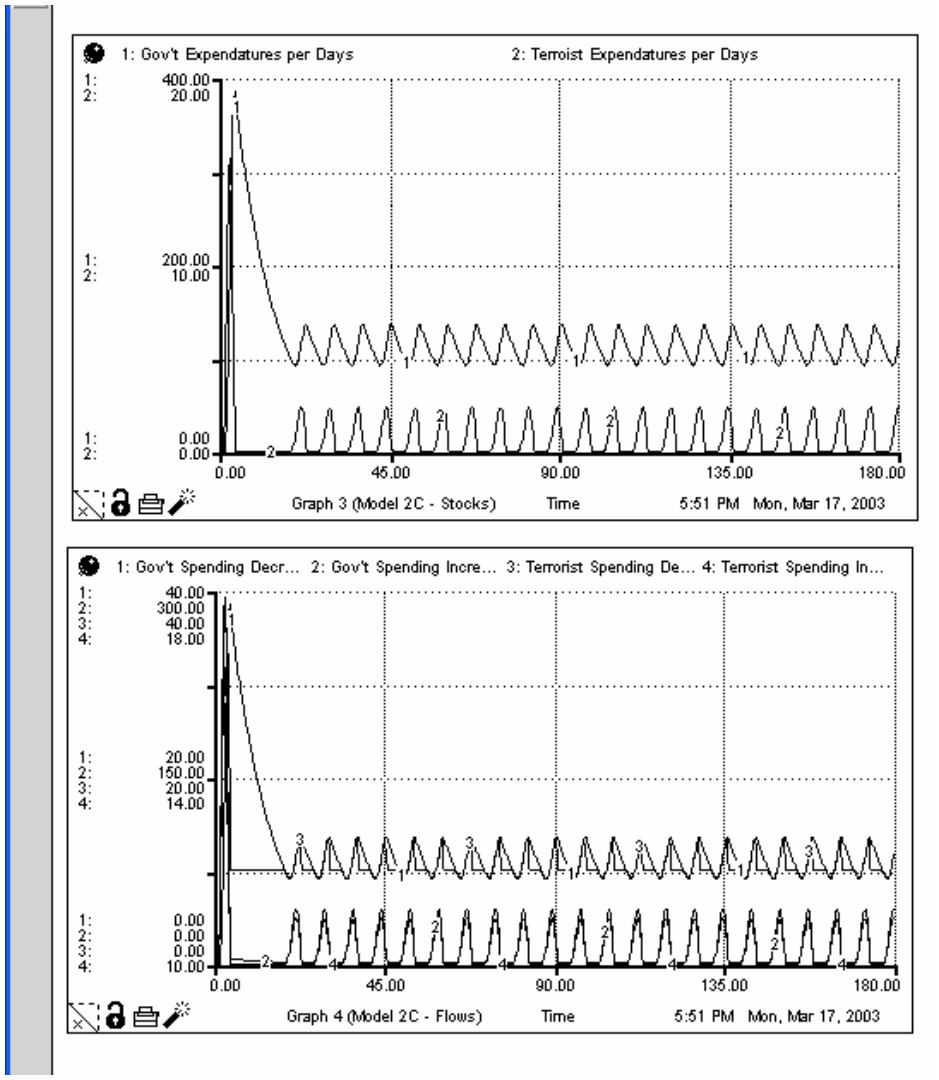


Figure 49. Model 2C Interface Level Screen Shot 2

A.2. Model 2C Map/Model Level

The map/model level displays the Stella® model in graphical format, as shown in Figure 50.

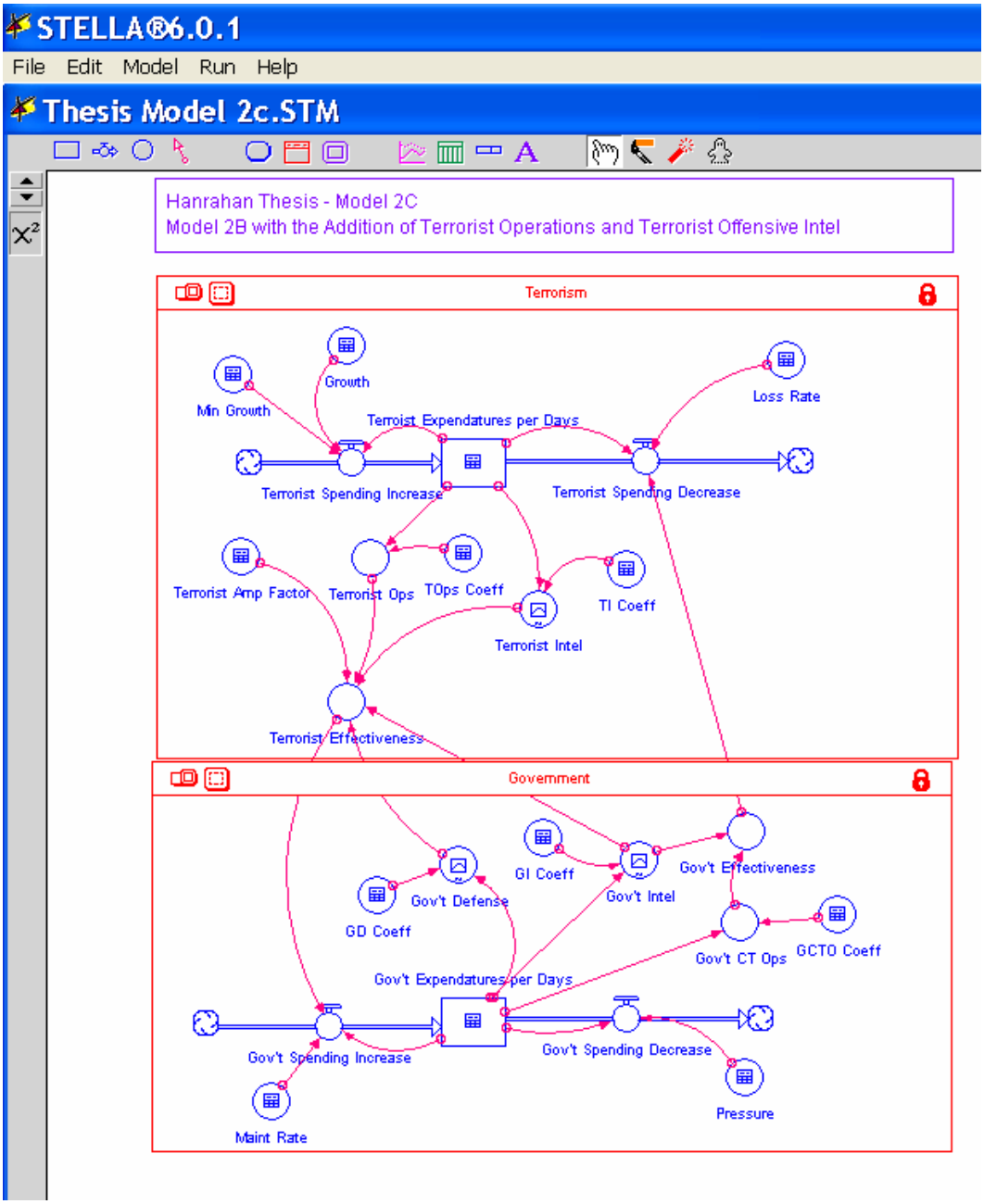


Figure 50. Model 2C Map/Model Level Screen Shot

A.3. Model 2C Equation Level

The equation level displays the mathematical equations used by Stella® to simulate the model, as shown in Figure 51.

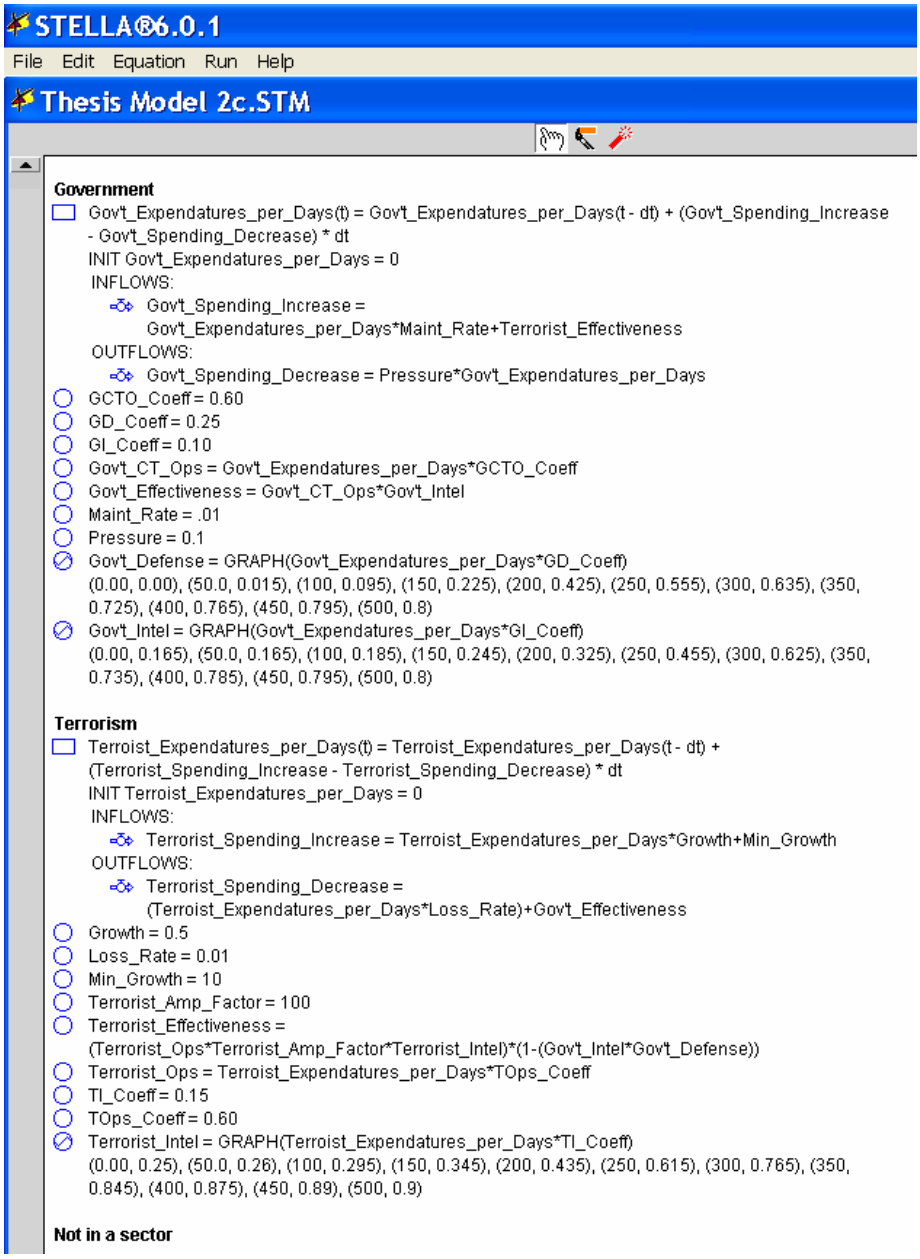


Figure 51. Model 2C Equation Level Screen Shot

Appendix B. Model Series 4 Final Model: Model 4K1

This appendix displays model 4K1 in its entirety as developed using Stella® 6.0. Model 4K1 was the final product of the series 4 modeling process and was one of two starting points for the final model developed in model series 5.

B.1. Model 4K1 Interface Level

The interface level is too large to fit on one screen shoot so it is shown in Figures 52 and 53. Figure 52 shows the model settings for the simulation run, the graphical variables and general comments on the model. Figure 53 shows the stock and flow graphs generated by the model's simulation run. The model run time is 365 days; however the graphs have been produced for only the first 180 days.

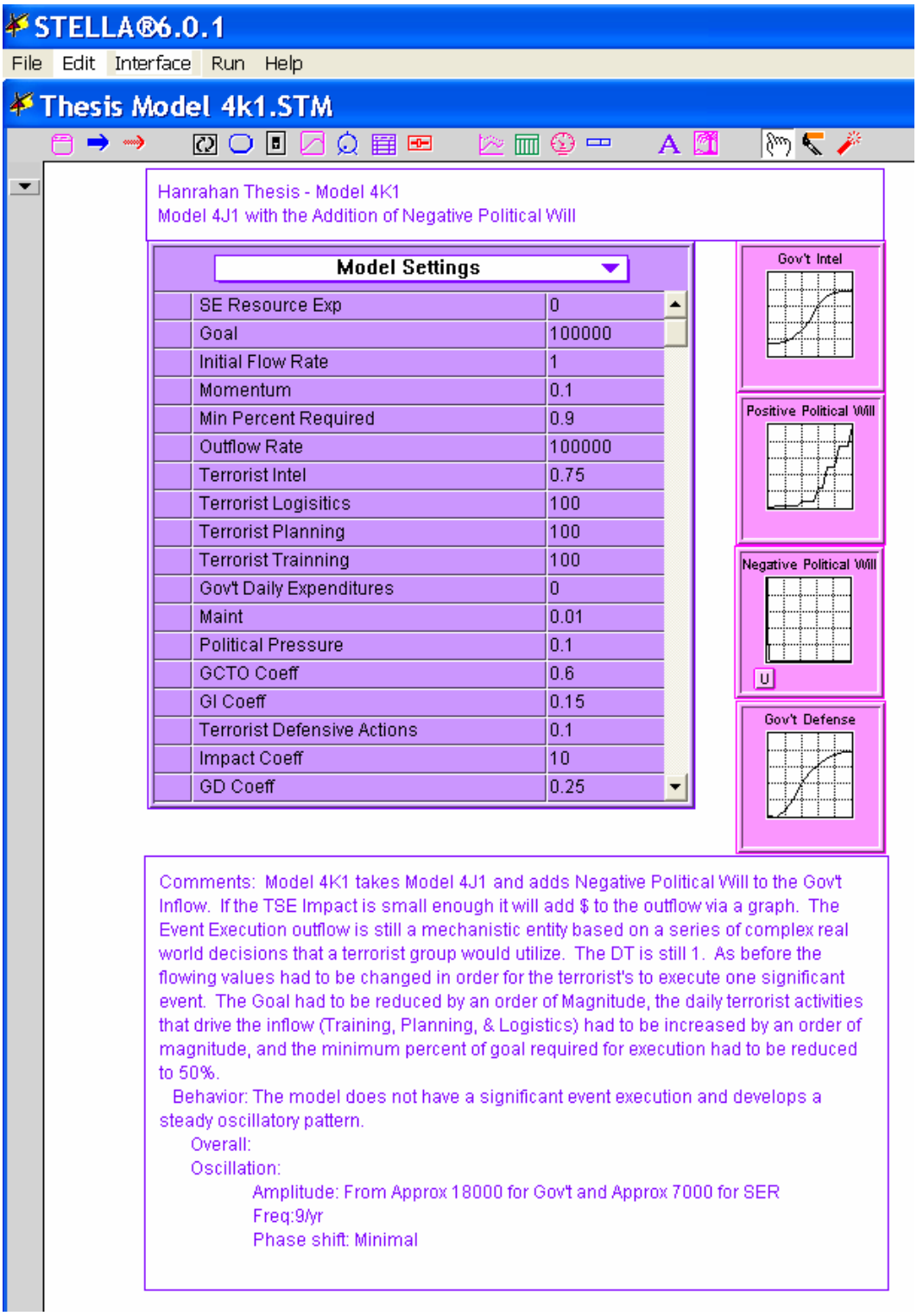
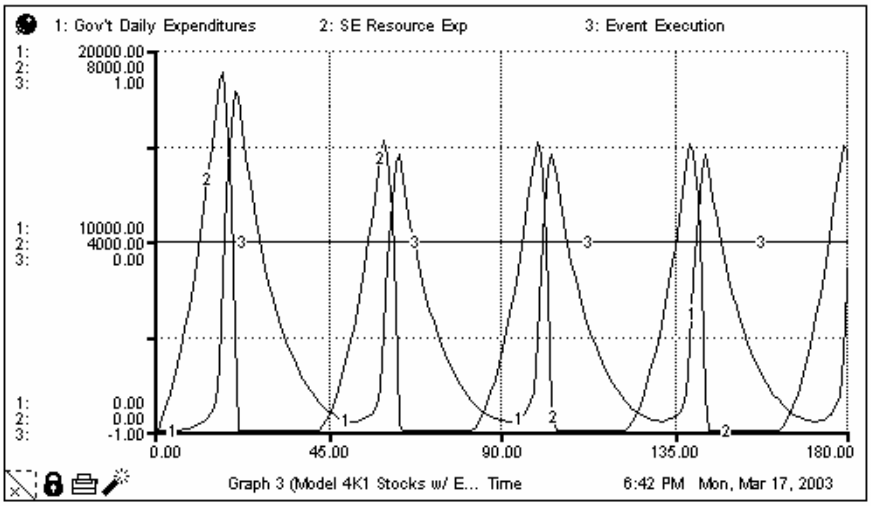


Figure 52. Model 4K1 Interface Level Screen Shot 1



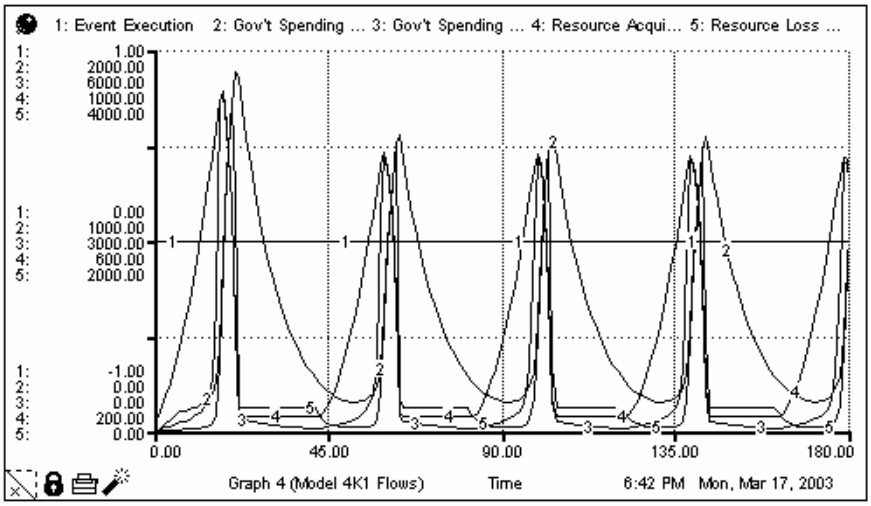


Figure 53. Model 4K1 Interface Level Screen Shot 2

B.2. Model 4K1 Map/Model Level

The map/model level displays the Stella® model in graphical format, as shown in Figure 54.

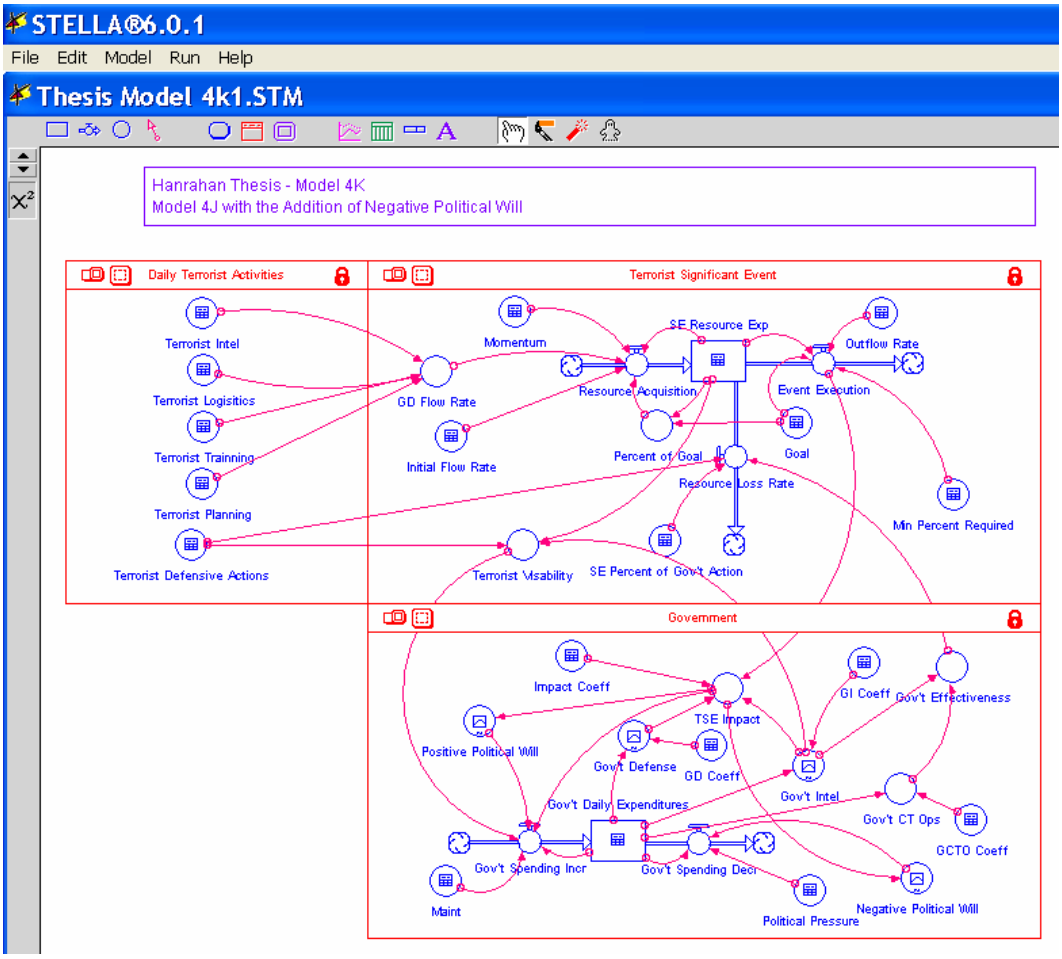


Figure 54. Model 4K1 Map/Model Level Screen Shot

B.3. Model 4K1 Equation Level

The equation level displays the mathematical equations used by Stella® to simulate the model, as shown in Figure 55 and 56.

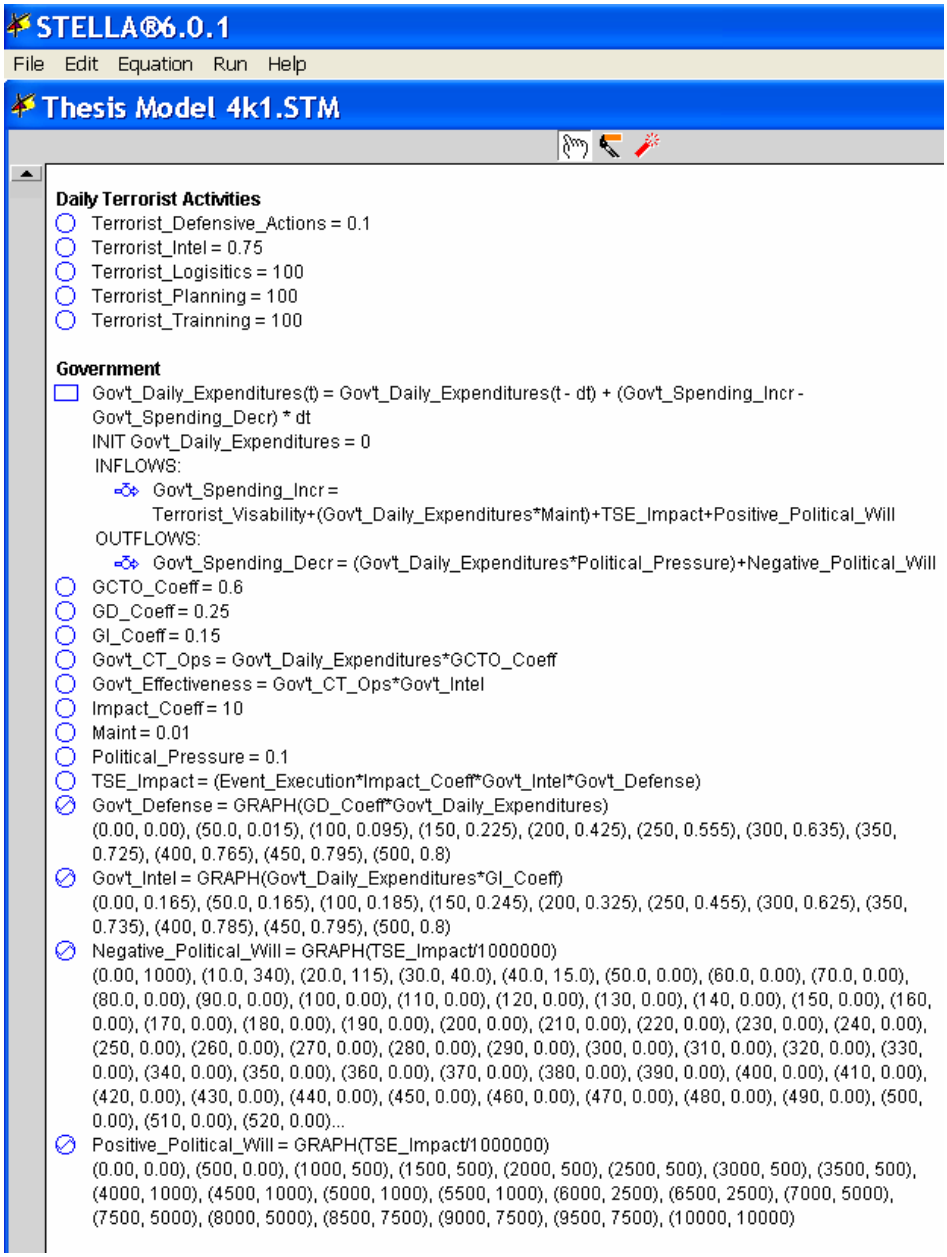


Figure 55. Model 4K1 Equation Level Screen Shot 1

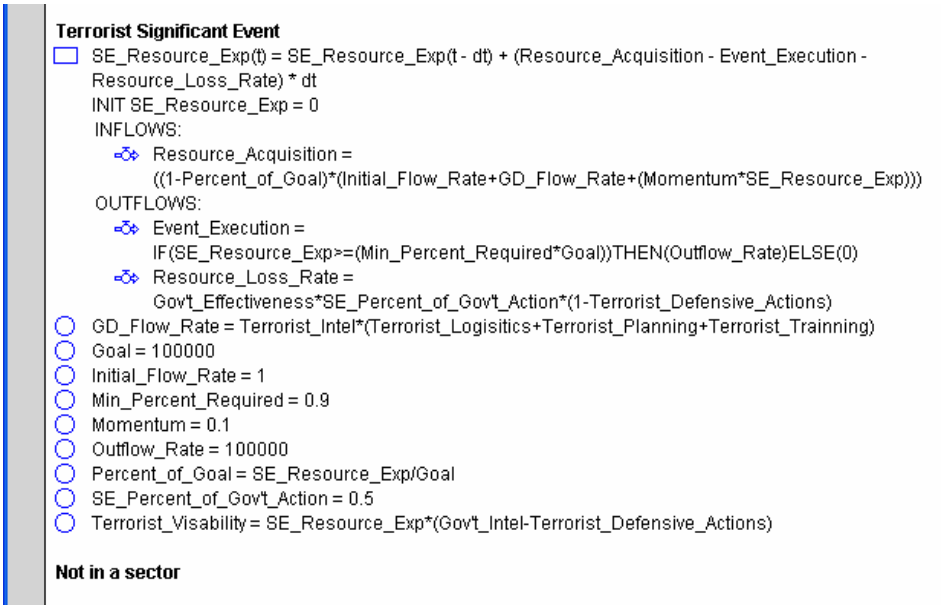


Figure 56. Model 4K1 Equation Level Screen Shot 2

Appendix C. Model Series 5 Final Model: Model 5D

This appendix displays model 5D, the final model, in its entirety as developed using Stella® 6.0. Model 5D is a modified combination of models 2C and 4K1 and was the final model for this research.

C.1. Model 5D Interface Level

The interface level is too large to fit on one screen shoot so it is shown in Figures 57 and 58. Figure 57 shows the model settings for the simulation run, the graphical variables and general comments on the model. Figure 58 shows the stock and flow graphs generated by the model's simulation run. The model run time is 365 days; however the graphs have been produced for only the first 180 days.

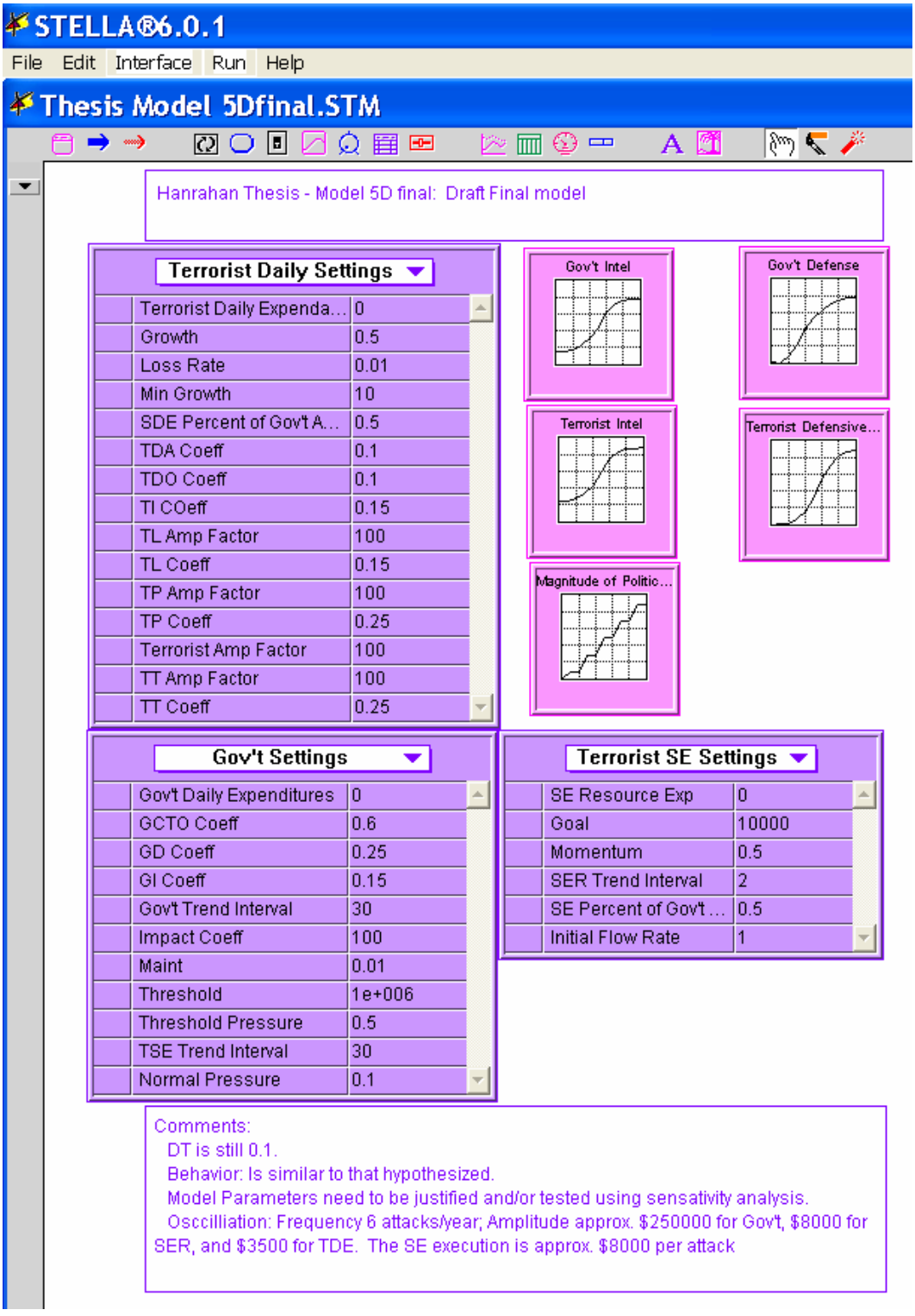


Figure 57. Model 5D Interface Level Screen Shot 1

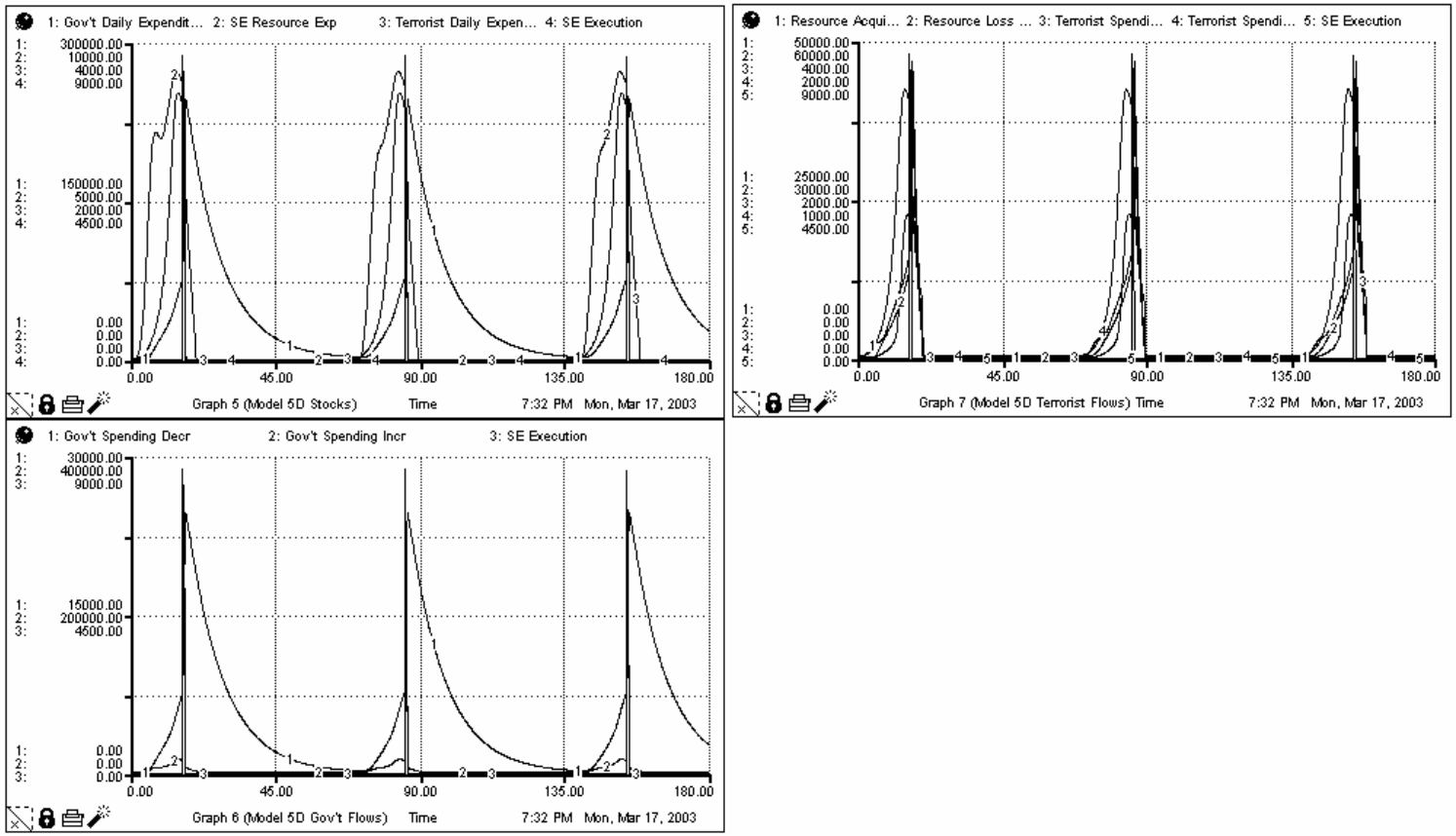


Figure 58. Model 5D Interface Level Screen Shot 1

C.2. Model 5D Map/Model Level

The map/model level displays the Stella® model in graphical format, as shown in Figure 59.

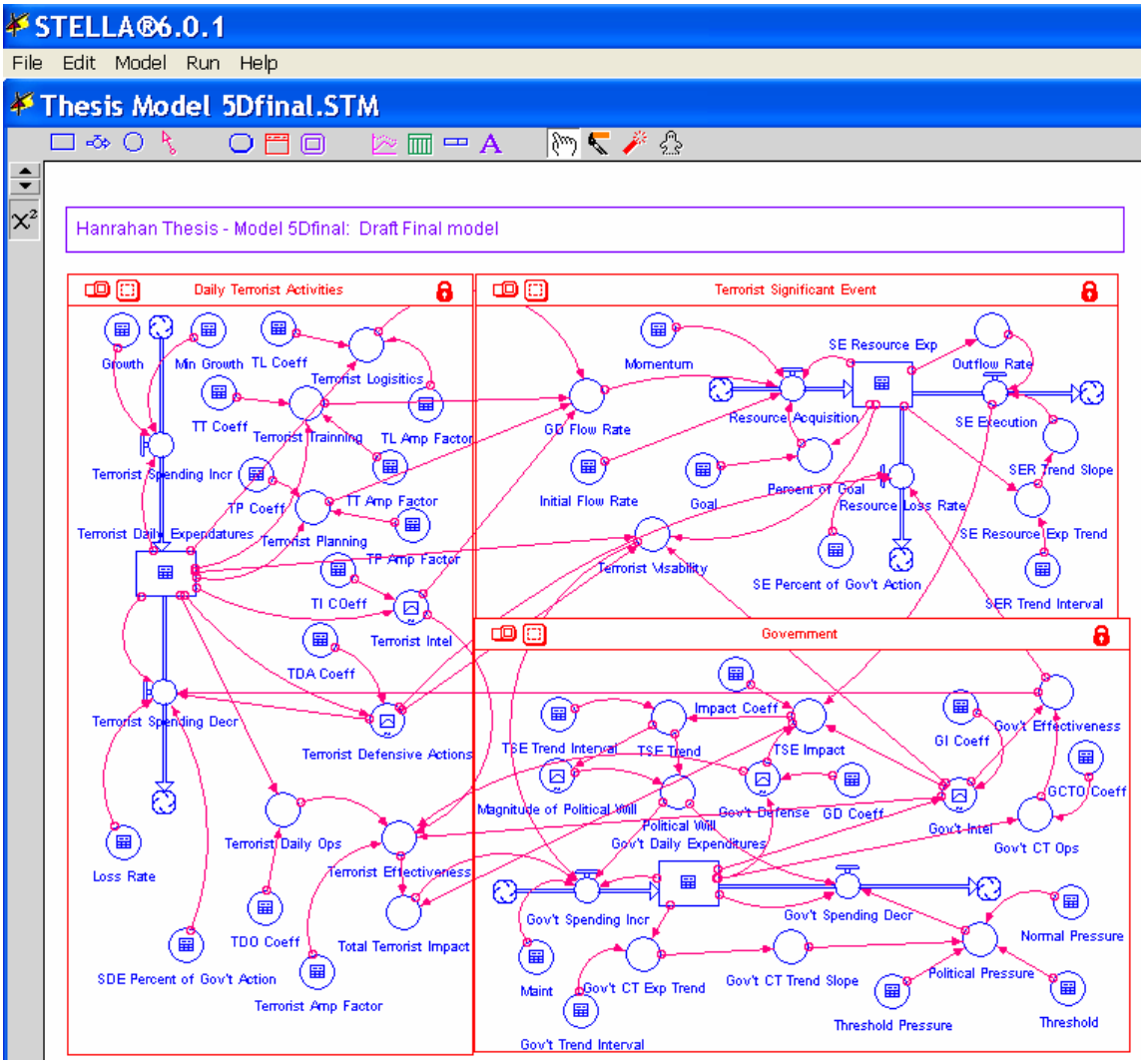


Figure 59. Model 4K1 Map/Model Level Screen Shot

C.3. Model 5D Equation Level

The equation level displays the mathematical equations used by Stella® to simulate the model, as shown in Figure 60, 61, and 62.

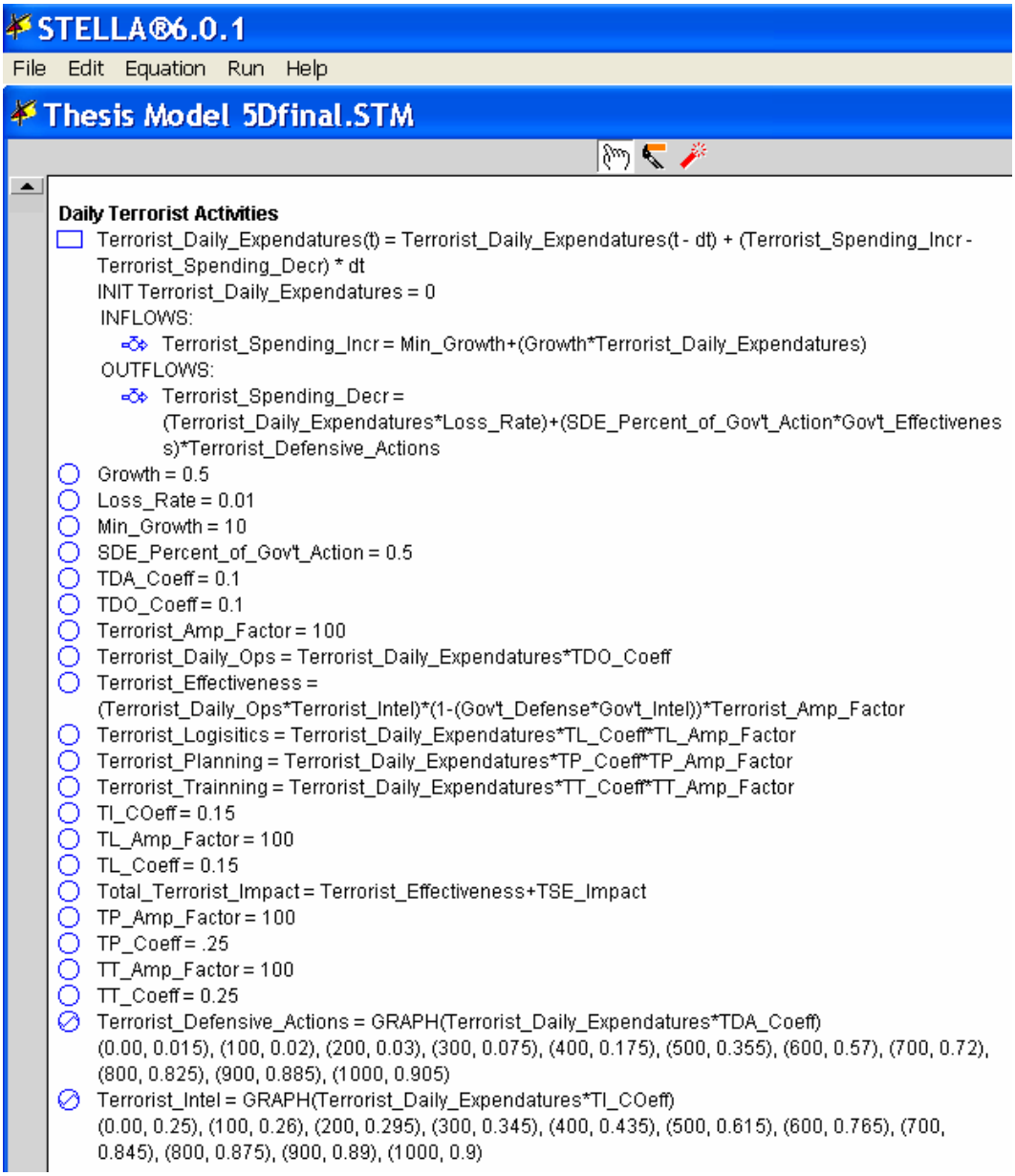


Figure 60. Model 5D Equation Level Screen Shot 1

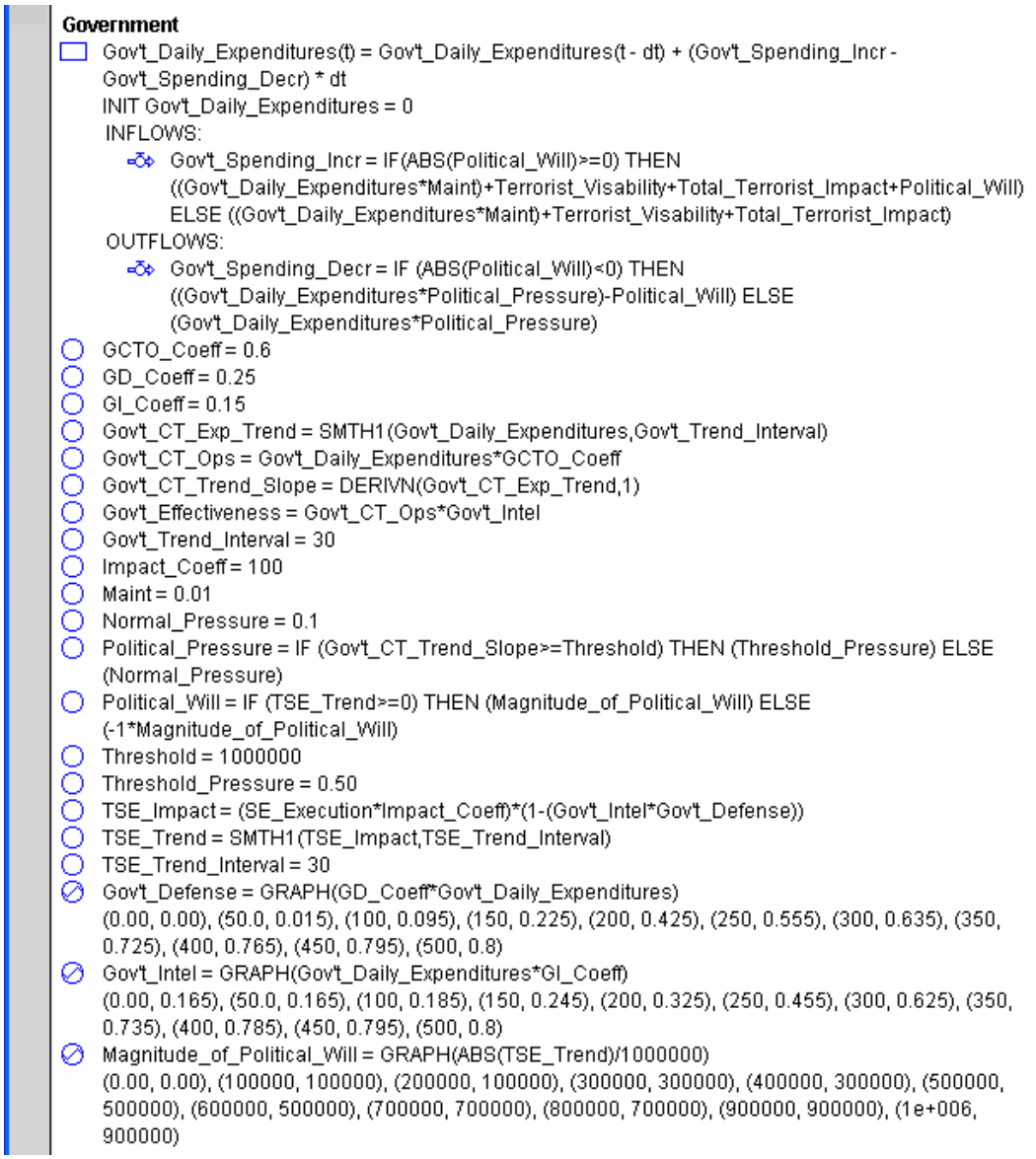


Figure 61. Model 5D Equation Level Screen Shot 2

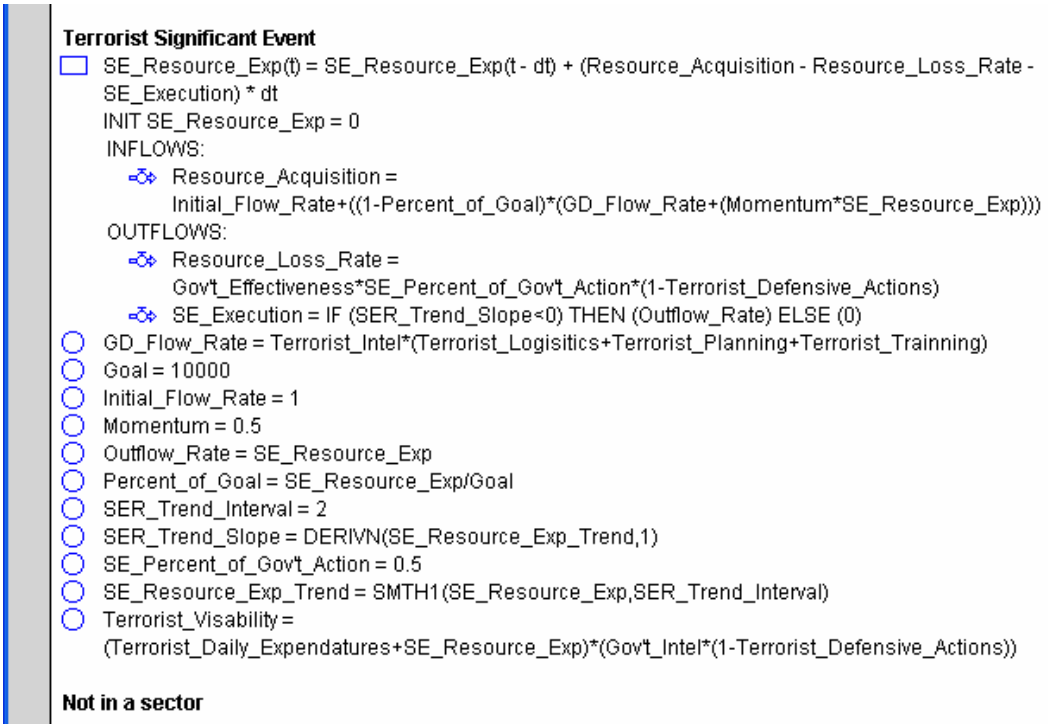


Figure 62. Model 5D Equation Level Screen Shot 3

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14. ABSTRACT

The nature of action and reaction that forms the basis for terrorist – government interactions creates a dynamic system. Understanding how this dynamic system behaves in response to key government activities can help the government better control the overall behavior of the system. The system dynamics methodology is one tool that can help the government solve specific behavioral problems within the overall system.

This research shows the ability of system dynamics to help develop government policy towards terrorism that can directly affect a terrorist's behavior. It supports a government policy of offensive action instead of defensive reaction. It also identifies the primary variables and parameters of the overall system at an aggregated level. This research effort is the genesis of a future research stream capable of helping the government manages their terrorism policy. The last chapter of this study suggests additional steps in this line of research to develop a tool that can help the government control the dynamic system of terrorist–government interactions.

15. SUBJECT TERMS

Terrorism, Counterterrorism, Behavioral Interactions, System Dynamics, Terrorist, Terrorist Organization, Al Qaeda, Terrorism Modeling

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